EFFECTS OF BREEDING SEASON AND INTER SE MATING ON BEEF COW PRODUCTIVITY

BY

ALEXIS POURRAIN

A DISSERTATION PRESENTED TO THE GRADUATE SCHOOL
OF THE UNIVERSITY OF FLORIDA IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

UNIVERSITY OF FLORIDA

1988

To my late parents and brother
Rodolfo Mario, Ana Maria and Ruddy

To my late parents-in-law
Domingo Jose and Rumilda del Carmen

To my wife and children
Rita, Alexis and Javier

ACKNOWLEDGEMENTS

I wish to express my sincere gratitude to all those persons and institutions which, in one way or another, supported me in my program.

I am especially grateful to Dr. Don D. Hargrove for his technical and academic guidance, advice and assistance, but most of all, for the concern and friendship shown towards me. Gratitude is extended to Drs. T.A. Olson, C.J. Wilcox, F.M. Pate and P.E. Hildebrand for their participation as members of my supervisory committee. I also wish to extend my appreciation to Linda D. Audette, Edgar Santos and Ricardo Borges for their help and friendship.

I also wish to express appreciation to my wife, Rita, and our sons, Alexis and Javier, for their support and understanding throughout the past two years.

I owe special gratitude and appreciation to my country and the Instituto Nacional de Tecnologia Agropecuaria (INTA), which provided the financial assistance necessary for the completion of my studies.

I have special thoughts for my late parents-in-law who, in life, supported and encouraged me for progress.

I have special thoughts for my late parents whose past efforts made possible many of my present achievements.

Finally, I wish to thank God for His guidance and protection given to me and my family.

TABLE OF CONTENTS

Page

ACKNOWLEDGEMENTS iii

LIST OF TABLES v

LIST OF FIGURES vii

ABSTRACT viii

INTRODUCTION 1

LITERATURE REVIEW 5

  Breeding Season 5
  Inter Se Mating 14

STUDY I: EFFECTS OF BREEDING SEASON ON BEEF COW PRODUCTIVITY . . . 19

  Introduction 19
  Experimental Procedure 20
  Results and Discussion 24
  Summary 42

STUDY II: COMPARISONS OF TWO BRAHMAN-ANGUS CROSSBRED GROUPS IN INTER SE MATING PROGRAMS 43

  Introduction 43
  Experimental Procedure 44
  Results and Discussion 49
  Summary 68

SUMMARY AND CONCLUSIONS 70

LITERATURE CITED 72

BIOGRAPHICAL SKETCH 77

LIST OF TABLES

Table Page

1. NUMBER OF COWS BY BREEDING GROUP AND BY BREEDING AND CALVING SEASON DATES 22

2. LEAST SQUARES MEANS ± STANDARD ERRORS AND PROBABILITY VALUES (P) FOR COW PRODUCTIVITY, COW WEIGHT, AND COW PRODUCTIVITY PER CWT BY BREEDING SEASON, YEAR, AND AGE GROUP OF DAM . . . 26

3. LEAST SQUARES MEANS ± STANDARD ERRORS AND PROBABILITY VALUES (P) FOR CALF BIRTH WEIGHT, WEANING WEIGHT AND PREWEANING AVERAGE DAILY GAIN BY BREEDING SEASON, YEAR, AGE GROUP OF DAM, AND SEX OF CALF 31

4. LEAST SQUARES MEANS ± STANDARD ERRORS AND PROBABILITY VALUES (P) FOR PREGNANCY, CALVING AND WEANING RATES BY BREEDING SEASON, YEAR, AND AGE GROUP OF DAM 37

5. LEAST SQUARES MEANS ± STANDARD ERRORS AND PROBABILITY VALUES (P) FOR STILLBORN RATE AND SURVIVAL OF CALVES FROM BIRTH TO WEANING BY BREEDING SEASON, YEAR, AND AGE GROUP OF DAM . . . 40

6. NUMBER OF BREEDING FEMALES PER YEAR BY BREED GROUP OF COW AND BULL 46

7. LEAST SQUARES MEANS ± APPROXIMATE STANDARD ERRORS AND PROBABILITY VALUES (P) FOR COW PRODUCTIVITY, CALF PERFORMANCE, REPRODUCTION AND CALF SURVIVAL TRAITS BY INTER SE BREEDING GROUP 51

8. LEAST SQUARES MEANS ± STANDARD ERRORS FOR COW PRODUCTIVITY MEASURES BY INTER SE BREEDING GROUP AND YEAR 52

9. LEAST SQUARES MEANS ± STANDARD ERRORS FOR WEANING WEIGHT AND PREWEANING AVERAGE DAILY GAIN (ADG) OF CALVES BY INTER SE BREEDING GROUP AND YEAR 54

10. LEAST SQUARES MEANS ± STANDARD ERRORS FOR PREGNANCY, CALVING, AND WEANING RATES BY INTER SE BREEDING GROUP AND YEAR 56

11. LEAST SQUARES MEANS ± APPROXIMATE STANDARD ERRORS AND PROBABILITY VALUES (P) FOR COW PRODUCTIVITY, CALF PERFORMANCE, REPRODUCTION AND CALF SURVIVAL TRAITS BY COW BREED GROUP . . 58

Table | Page

12. LEAST SQUARES MEANS ± STANDARD ERRORS FOR COW PRODUCTIVITY MEASURES BY COW BREED GROUP AND YEAR 59

13. LEAST SQUARES MEANS ± STANDARD ERRORS FOR PREWEANING AVERAGE DAILY GAIN (ADG) OF CALVES BY COW BREED GROUP AND YEAR . . . 61

14. LEAST SQUARES MEANS ± APPROXIMATE STANDARD ERRORS AND PROBABILITY VALUES (P) FOR COW PRODUCTIVITY, CALF PERFORMANCE, REPRODUCTION AND CALF SURVIVAL TRAITS BY COW BREED GROUP . . 63

15. LEAST SQUARES MEANS ± STANDARD ERRORS FOR COW PRODUCTIVITY AND COW PRODUCTIVITY PER CWT BY COW BREED GROUP AND YEAR . . 64

16. LEAST SQUARES MEANS ± STANDARD ERRORS FOR WEANING WEIGHT AND PREWEANING AVERAGE DAILY GAIN (ADG) OF CALVES BY COW BREED GROUP AND YEAR 66

LIST OF FIGURES

Figure Page

1. BREEDING SEASON X YEAR INTERACTION EFFECTS ON COW PRODUCTIVITY. 28

2. BREEDING SEASON X YEAR INTERACTION EFFECTS ON COW PRODUCTIVITY PER CWT. 28

3. BREEDING SEASON X YEAR INTERACTION EFFECTS ON COW WEIGHT. 30

4. BREEDING SEASON X AGE GROUP OF DAM INTERACTION EFFECTS ON COW WEIGHT. 30

5. BREEDING SEASON X YEAR INTERACTION EFFECTS ON CALF BIRTH WEIGHT. 33

6. BREEDING SEASON X YEAR INTERACTION EFFECTS ON WEANING WEIGHT. 35

7. SEX OF CALF X YEAR INTERACTION EFFECTS ON AGE ADJUSTED WEANING WEIGHT. 35

8. BREEDING SEASON X YEAR INTERACTION EFFECTS ON PREWEANING AVERAGE DAILY GAIN (ADG) OF CALVES. 36

9. SEX OF CALF X YEAR INTERACTION EFFECTS ON PREWEANING AVERAGE DAILY GAIN (ADG) OF CALVES. 36

Abstract of Dissertation Presented to the Graduate School
of the University of Florida in Partial Fulfillment of the
Requirements for the Degree of Doctor of Philosophy

EFFECTS OF BREEDING SEASON AND INTER SE MATING ON BEEF COW PRODUCTIVITY

By

Alexis Pourrain

August, 1988

Chairman: Don D. Hargrove
Major Department: Animal Science

Two studies were conducted at the Everglades Research and Education Center, Belle Glade, Florida. In the first study, the effects of three 70-day breeding seasons (November 1-January 10, January 1-March 11, and February 15-April 25) on beef herd productivity were compared over a 4-year period. Beefmaster cows sired by certified Beefmaster bulls were used in this study. Response variables studied were reproductive behavior measured as pregnancy, calving, and weaning rates, and calf survival, calf birth and weaning weights, and cow productivity. Breeding season did not significantly affect any of the response variables. Year affected ($P<.05$) all response variables except calf birth weight and survival. Age of dam affected pregnancy ($P<.01$), calving ($P<.01$) and weaning ($P<.06$) rates, and cow productivity ($P<.06$).

In the second study, performance of two Brahman-Angus crossbred populations mated inter se were compared. The two populations were 3/8 B:5/8 A (Brangus) and 1/2 B:1/2 A (F_1BA). Cow breed groups (Brangus,

F_1BA and F_2BA) were also compared. Data from six mating seasons (751 cow and 611 calf records) included reproductive behavior measures, growth parameters, and cow productivity measures. Cow productivity ($P<.03$) and calf growth parameters ($P<.0001$) from the F_1BA population were higher than those from the Brangus population. Calf survival traits did not differ between the two inter se groups, but reproductive behavior of cows from the F_1BA group was superior to that of the Brangus group. Overall performance of the F_1BA cows and their F_2BA calves was superior to that of Brangus cows and calves, and F_2BA cows and their calves. Except for calf birth weight and preweaning ADG, performance of the F_2BA cows and their calves tended to be similar to that of Brangus cows and calves. Significant cow breed group x year interaction effects were found for several traits.

INTRODUCTION

A major goal of production oriented beef cattle research, in order to contribute to improved efficiency of beef production, is to gain the necessary understanding to combine existing resources in the best possible way to achieve defined objectives.

Productivity of a commercial cow-calf operation is the product of average weaning rate and average weaning weight of the calves. The level of expression of both of these traits depends heavily on the nutritional status and genetic potential of the herd, especially for the preweaning period. Under extensive or semi-extensive management, as most commercial cow-calf systems are operated, available forage and beef cattle germplasm are among the most important production resources.

During the preweaning period a cow has to produce enough milk to adequately nourish her calf, recover from the stress of the preceding pregnancy and calving, and rebreed during a fixed breeding season of not more than 60 to 90 days. The calf to be efficient has to achieve rapid weight gains to reach the heaviest weight possible by the scheduled weaning date. Calf weaning weight is influenced primarily by average daily gain (ADG) from birth until weaning and by age at weaning. The calf's ADG is basically dependent on his genetic potential and nutritional status, and the latter is closely related to the dam's milk production.

Weaning rate of the herd is determined by the percentage of breeding females that conceive during the breeding season and the subsequent losses that occur between pregnancy and weaning. These losses may occur during both the pre- and post-natal stages.

Most commercial cow-calf operations throughout Florida are grazing operations, with native range and improved pasture as the main feed sources. Establishing a short, fixed breeding season is of utmost importance in a pasture-based cow-calf system, due to the seasonal forage production of the pastures (i.e. quantity and quality). A series of managerial advantages are brought together with the establishment of a breeding season. Basically, a breeding season should synchronize the herd's nutrient requirements with the available forage, the cheapest source of feed in the operation. Additionally, by determining pregnancy via rectal palpation, the animals in the herd can be classified into production categories according to nutrient requirements, thus allowing for a more rational and efficient assignment of available feed resources (i.e. pastures and feedstuffs). Use of a fixed breeding season facilitates culling of breeding females with lower fertility. A more uniform calf crop, because of more uniform age due to the use of a short breeding season, facilitates the application of a series of practices related to management (i.e. castration, deworming, dehorning), weaning, and sale of the calves.

Calf production in Florida is highly seasonal, with most calves marketed from July through October. This seasonal marketing is not unique to Florida, but occurs throughout the United States. The result is a seasonal fluctuation in feeder calf prices and an uneven supply of cattle to feeders, stockers, and packers.

The climatic conditions of south Florida are conducive to good year-round forage production. This enables the cattleman to establish his breeding season for the time of year best suited to his convenience and to other facets of his operation.

The humid tropical and semi-tropical regions offer a great potential for beef production; however, the factors determining most of the potential, high temperature and humidity, create conditions that negatively affect performance and efficiency of production in nonadapted cattle. One way to overcome these constraints is by utilizing adapted and productive cattle. Zebu-European crossbreds have demonstrated their superiority as compared to European-European crosses, especially for tropical conditions. Experimental results and practical application seem to favor two- and three-breed rotational crossbreeding over other alternative schemes for exploiting heterosis and for combining desired characteristics. However, size of the herd and level of managerial capability restrict the adoption of a systematic rotational crossbreeding program by many producers in important beef producing countries in the world, including the U.S.A.

The use of composite (synthetic) breeds or of crossbred cows and bulls in an inter se mating program appears to be a valid alternative to systematic crossbreeding for the exploitation of heterosis, without many of the practical limitations of rotational crossbreeding. Santa Gertrudis, Brangus, Braford, Simbrah and most other modern American breeds were developed from crossbreeding followed by inter se mating. Most American breeds have a 5/8 European 3/8 Zebu breed composition.

The objectives of these studies were:

I) to compare the effects of three breeding seasons on productivity of a commercial cow-calf system in south Florida, and

II) to compare productivity of 3/8 B:5/8 A (Brangus) and 1/2 B:1/2 A (F_1BA) inter se mated populations in a commercial cow-calf system in south Florida.

LITERATURE REVIEW

Breeding Season

When a given genetic potential for production has been reached and a good herd health program has been established, the reproductive and productive efficiency of a commercial cow-calf operation is determined primarily by the level of nutrition available to the herd. Since native range and cultivated pastures represent the most important food sources for the commercial beef herd, the goal of good management should be to make the most intensive and efficient use possible of available pastures. Establishing a short, fixed breeding season at the correct time of the year is fundamental to sound beef herd management, since it permits the matching of quality and quantity of pasture available with changes in nutrient requirements of the breeding herd.

Reproductive Parameters

From a practical standpoint, commercial cow-calf producers must be concerned with the reproductive performance of their cow herds. Wiltbank et al. (1961) analyzed factors affecting net calf crop in beef cattle and concluded that major losses in potential calf crop were the result of failure to conceive, of early embryonic death before pregnancy diagnoses, and of calf death at or shortly after birth. Among the most important factors that affect the previously mentioned losses are season of the year, year, and age of dam. These affect or are closely related to the nutritional and environmental conditions of the cows and calves.

Preston and Willis (1970) stated that the published data support the contention that an increasing plane of nutrition during the breeding season is probably the most important single factor involved in achieving high pregnancy rates and consequent good calf crops. Peacock et al. (1976) found average pregnancy rates in Florida to be 64%, 76% and 81%, respectively, on native range, a combination of native range and improved pasture, and improved pasture. The average weaning rates for the three pasture programs were 63%, 73% and 76% respectively.

Warnick (1963), referring to a survey conducted in Florida, reported that the average pregnancy rate on 13 private ranches was 69%, compared to 77% in five station herds. The author pointed out that a higher nutritional plane and a more carefully controlled breeding season in station herds would explain at least part of the observed differences. Marked differences between private and station herds for pregnancy rates of lactating and non-lactating cows and for pregnancy rates of lactating first-calf cows were also found in this study. Reynolds et al. (1979) also found a reduced pregnancy rate (-10.9%) for lactating first-calf cows, as compared to the average of older lactating cows.

Oliver (1987), in a comprehensive study on the lifetime performance of purebred and crossbred beef cows in Louisiana, recorded an overall calving rate of 87.8% and a corresponding weaning rate of 80.1%. Losses between pregnancy and calving were negligible.

At the Beef Research Unit of the University of Florida, Gainesville, Florida, different pasture programs were evaluated in a systems approach. The project was conducted in three phases and had a duration of 21 years, from 1952. Different sets of pasture programs were compared during the three phases (Koger, 1977, 1983a,b).

They reported that calving rates varied from a low of 63% to a high of 98.6%, and that the top weaning rate was about 95%. The overall conclusion from this project was that it was possible, with good herd management and adequate nutrition, to achieve calf crops of over 90% in Florida.

Bagley et al. (1987), in Louisiana, compared the productivity of cow-calf systems managed for fall and spring calving seasons. They found no difference between the two seasons for pregnancy rate (93.2% vs 92.4%). Weaning rate for the fall calving system was higher, however, due to a lower calf loss from calving to weaning. In north central Florida, Cornwell et al. (1984) compared cow production of fall and winter calving programs with purebred Angus and Brahman herds. Cow production and calf performance of the Angus breed did not differ between fall and winter calving; however, cow productivity for the Brahman breed decreased each year in the fall-calving program and increasing numbers of cows failed to conceive each year for fall calves. Brahman cows did conceive during the following 90 days, thus producing winter calves. The authors suggested that a longer gestation period for fall-born calves, later expression of first estrus after calving, and loss of weight or failure to gain enough weight during the breeding season to conceive for fall calving as reasons for the observed reproductive performance of the Brahman.

Not all cows that conceive wean a calf. Abortions between time of palpation for determination of pregnancy and calving, calves born dead (stillbirths), calves that die within 72 hours of birth, and calves that die between 72 hours after birth and weaning are the losses that can occur between pregnancy diagnoses and weaning. Assuming small errors in palpation and a good health status of the herd, most losses are likely to occur at or shortly after birth. Koger et al. (1967) analyzed records from 3408 calves born at four experimental stations in Florida and reported that of the calves that failed to survive 6.2% were aborted, 50.8% died within 24 hours of birth, 12% died between 24 and 72 hours after birth, and 30.8% died later than 72 hours after birth. Reynolds et al. (1980) reported, from a study conducted in Louisiana, that of the total calves lost, 68.2% were dead at birth or died within the first 72 hours postpartum. Similarly, Long and Gregory (1974) reported 69% of the calves lost were dead at birth or died within 72 hours after parturition. In a comprehensive study on characterization of biological types of cattle, Gregory et al. (1978) and Gregory et al. (1979) found average perinatal mortalities of 4.8% and 3.2%, average calf crops weaned of 93.7% and 93.6%, respectively, and also found that two-thirds and one-half of the preweaning mortalities occurred at or within 72 hours of birth. Woodward and Clark (1959) reported, from observations on 8857 births, that stillbirths occurring in the beef herds at the U.S. Range Livestock Experiment Station in Montana averaged 3.6% for the period 1936 through 1957. Laster and Gregory (1973), analyzing data collected from 1967 to 1972 on 5064 parturitions, found an overall calf mortality of 8.6%, and they reported that the mortality rate was not affected by year or season of birth.

Reviewing the research needs in beef cattle reproduction, Wiltbank (1970) confirmed that most calf losses, ranging from 5 to 14%, occurred at or shortly after birth and that 50% of the calves lost at birth could be saved by improved management.

Growth Parameters

The ultimate goal of a commercial cow-calf system should be to produce the greatest number of calves, with the heaviest weight, in the shortest time, and at the least possible cost. Together with reproductive efficiency, individual growth measured as birth weight, preweaning average daily gain (ADG), and weaning weight is of major importance in determining the overall productivity of a commercial cow-calf operation.

Calf birth weight has important implications in a cow-calf operation. Positive genetic relationships have been found between birth weight and postnatal growth (Cundiff, 1977). Conversely there are indications that a portion of calving difficulties is caused by excessively heavy birth weights (Oliver, 1987).

Breed and breed cross is the most important single factor affecting calf birth weight. Sex of calf, age of dam, and year are among the factors considered environmental that affect birth weight. Koonce and Dillard (1967), reporting data from Hereford calves at four North Carolina locations, found that year influenced birth weight and that bull calves weighed 1.6 kg more at birth than heifers. In the same study, dams 3 and 4 years of age produced calves weighing 2.64 and .95 kg less at birth, respectively, than the overall herd average. Reynolds et al. (1980) studied factors influencing gestation length, birth weight and calf survival of Angus, zebu and zebu crosses and did not find differences among years for any of the traits studied. They did, however, find that age of dam affected birth weight.

Working in Louisiana from 1932 through 1957 with Brahman-Angus and Africander-Angus crossbred cattle, Vernon et al. (1964) found no differences in birth weight due to year, but did find that males were heavier at birth than females (29.9 vs 27.6 kg for the Brahman crosses and 29.5 vs 27.8 kg for the Africander crosses). Age of dam influenced birth weight. The Brahman-Angus 2-and 3-year-old dams gave birth to the lightest calves, and birth weight increased with increasing age of dam. Africander-Angus cows bred for the second time (4-year-olds) gave birth to the lightest calves among the Africander-Angus crossbreds. The authors also found that calves born from December 1 to January 31 had lighter birth weights (27.5 kg) than calves born from February 1 through May 31 (29.4 kg). Koch and Clark (1955) showed that Hereford bull calves were 2.5 kg heavier at birth than heifers and that age of the dam had a marked influence on birth weight, with birth weight increasing steadily as dam age increased from 3 to 6 years and then declining. Smith et al. (1976), Gregory et al. (1978), Notter et al. (1978), and Gregory et al. (1979) worked with different breeds of cattle and found that male calves were heavier at birth than females, with differences for the respective studies of 2.7, 3.0, 4.0 and 2.1 kg.

Other important components of productivity of a commercial cow-calf operation are preweaning average daily gain and weaning weight. Calving rate and calf survival to weaning determine the number of calves produced by the cow herd, and weaning weight determines the kilograms of calf produced. The combination of these factors determines gross return (Oliver, 1987). Weaning weight is of interest in a cow-calf operation, not only because of its immediate economical implications through the sale of steer calves and cull heifers, but also because of its associated effects on management of replacement heifers and age at first calving. Environmental factors that influence weaning weight and ADG from birth to weaning include year, season of birth, age of dam, and sex of calf.

Marlowe et al. (1965) collected data on 111 Angus and 82 Hereford herds in Virginia, where calves were and were not creep fed. They found that steer calves grew 6% faster than heifer calves regardless of whether or not they were creep fed. Calves dropped during March and April had the highest ADG, while calves born during August and September had the lowest daily gains. Creep feed tended to decrease the magnitude of the difference due to season of birth. An earlier study by Marlowe and Gaines (1958) also showed that creep feeding significantly decreased the influence of season of birth. Marlowe et al. (1965) also found a significant effect of age of dam on calf performance. They reported that ADG of calves increased as dam age increased from 2 to 7 years, then remained constant as dam age increased from 7 to 11 years.

Meade et al. (1963), working with data on Angus, Brahman, Devon, Brahman-Angus and Brahman-Devon cattle in south Florida, found significant effects for year, sex, month of birth and age of dam on adjusted 205-day weight. Average weaning weight by year ranged from a high of 189 to a low of 123 kg. Steer calves averaged 9.2 kg (5.7%) heavier at 205 days of age than heifer calves. Calves born from December through June were 8.3 kg heavier than those born from July through October, and calves born in November were 5.4 kg heavier than the latter. Calves from cows that calved at 2 years of age were the lightest (155.2 kg), and there was a steady increase in 205-day weight as cow age increased up to 6 years.

Peacock et al. (1966), in Florida, found that winter-born calves were heavier at 180 days of age (171.7 vs 165.3 kg) than spring-born calves. They suggested that this difference was probably due to heavier milk flow of the dams and to calves having access to more nutritious forage when they needed it for growth. Brown (1960), studying three purebred Hereford and Angus herds in Arkansas, reported a range of differences in 240-day calf weight due to year of 39, 32 and 39 kg for the three herds. Fall-born calves were 8.5 kg lighter at 240 days of age than spring-born calves. Males averaged about 17 kg heavier than females.

In Florida, Cornwell et al. (1984) did not find a difference in performance between fall-born (September 15 to December 15) and winter-born (December 15 to March 15) calves, but did find significant differences in calf performance among years. Similarly, Minyard and Dinkel (1965), Franke et al. (1977), Crockett et al. (1978a) and Prichard et al. (1982) reported significant effects of year, season of birth, sex of calf, and age of dam on weaning weight and ADG from birth to weaning.

Productivity Measures

Reproductive efficiency parameters and individual growth measures each take into account only one aspect of production efficiency in a beef cow-calf system. Developments in research and industry have intensified interest in total efficiency of beef production (Crockett et al., 1978a). One of the most commonly used measures of total efficiency of a cow herd is kilograms of calf weaned per cow in the breeding herd. This is often referred to as cow productivity. Spitzer and Sprott (1986) recorded improvement from 123 to 228 kg of calf weaned per cow during a 9-year period on a ranch in Texas, where management improved over time. Peacock et al. (1976), in a study on beef production of

Brahman, Shorthorn and their crosses on different pasture programs in Florida, reported an average production per cow of 135 kg, with values for pasture programs varying from a low of 102 kg for the native range to a high of 159 kg for the highly improved pasture program.

Koger (1977) analyzed the results of a 7-year study where the production of a cow-calf system was measured under three different pasture programs, (conventional clover-grass, renovated clover-grass and irrigated clover-grass pastures). Calf production per cow averaged 202, 198 and 210 kg, respectively, for the three programs. Cow productivity was also expressed in this study as kilograms of calf per 100 kg of cow, that is, as a percentage of cow weight. The mean productivity expressed in this form was 39.8%.

In Florida, comparing five pasture programs at the Beef Research Unit of the University of Florida, Koger et al. (1983a) reported cow productivity ranging from a low of 210 kg to a high of 232 kilograms of calf weaned per cow exposed to the bull. Koger et al. (1983b) also reported values that ranged from 119 to 171 kg of calf per cow exposed, in a comparison of eight pasture programs.

Crockett et al. (1978b), evaluating the effects of crossbreeding on cow productivity, expressed the trait as annual production of calf as a percentage of cow weight. The authors found a mean value of 32% and a range that varied from a low of 26% for straightbred Brahman to a high of 39% for Angus-Brahman crosses.

Inter Se Mating

One of the most important resources available to cattlemen is the existing cattle germplasm, namely, the available breeds of cattle. Rational use of this resource may contribute significantly to a productive and efficient operation. Differences among breeds arise partly because of selection for different objectives and (or) selection under very different environmental conditions, and partly from cumulative random changes in gene frequency (Lush, 1946; Philips, 1961). The mentioned differences have their expression in the individuals of the breeds through variable reproduction, growth rates, sizes, ability to survive, and carcass characteristics. Variability among breeds is mainly due to differing gene frequencies, average heterozygosity, and epistatic combination effects on performance (Dickerson, 1973). The genetic diversity among breeds provides an important potential for genetic improvement in the efficiency of food production from livestock through (1) grading-up to superior breeds, (2) heterosis from crossbreeding, and (3) development of new breeds (Dickerson, 1969; Lopez-Fanjul, 1974).

Most improved breeds of cattle were developed in temperate areas of the world. Humid tropical and semitropical regions offer a great potential for beef production, but high temperatures and humidity create conditions that impose severe restrictions in the performance of nonadapted cattle. The profile of beef cattle for the tropics is contrasting to that of improved European beef breeds. The basic requirements for beef cattle in the tropics are adaptability and tolerance to diseases and insects of the tropics, tolerance for high solar radiation, ability to efficiently use the fibrous roughages of the tropics, and adaptation and tolerance to high temperatures and humidity (Koger, 1973).

Exploitation of hybrid vigor, through systematic crossbreeding, offers an efficient and quick way to improve productivity and efficiency levels in commercial cattle operations (Dickerson, 1969; Koger, 1973). Performance in beef cattle herds is mainly governed by two cow traits, weaning rate and maternal ability, and by growth rate of the calf. The primary objective of a crossbreeding program in commercial operations should be to maximize the sum of the additive genetic values and heterosis levels for the above mentioned traits (Koger, 1980). Dickerson (1973) supported and added to the preceding concept by stating that the genetic diversity among existing breeds of cattle permits great potential flexibility in obtaining quickly the genetic characteristics best suited to particular management conditions and market preferences through the utilization of both transmitted and heterotic effects on individual and maternal performance. Cundiff (1970, 1977), Gregory and Cundiff (1980), and Long (1980) have extensively reviewed results from crossbreeding, and reported heterotic effects and heterosis values for most traits of economical importance. Earlier, Preston and Willis (1970) suggested that there was enough evidence to justify crossbreeding to exploit heterotic effects, although the relative merits of different crossbreeding systems were not clearly defined.

Heterosis levels are mainly determined by the breeds and crossbreeding scheme utilized. Several authors have agreed that crossbreeding of zebu with European breeds offers many advantages for production in tropical and semitropical regions, and that a rotational crossbreeding scheme, using two or three breeds, would retain sufficient heterosis as to make it worthwhile (Cundiff, 1970; Koger et al., 1973; Crockett et al., 1978a,b; Gregory and Cundiff, 1980; Peacock and Koger, 1980).

Rotational crossbreeding systems provide for greater utilization of heterosis (Cundiff, 1977) but do have some practical limitations. Variation in the types of animals produced, with the zebu-like calves discounted in price when marketed, and the fact that herd size and managerial skills limit the feasibility of a systematic and efficient crossbreeding scheme for many producers, are the major constraints to a wider adoption of rotational crossbreeding.

Use of composite (synthetic) breeds or of crossbred cows and bulls in an inter se mating scheme offers a valid alternative for exploiting the benefits of heterosis and of combining desirable traits from two or more parental breeds. Synthetic breeds or populations retain much of the advantages obtained from rotational crossbreeding without many of its practical constraints, and with the added potential of some heterosis in male reproductive performance (Lasley, 1981; Peacock et al., 1981; Thrift and Aaron, 1987).

Inter se mating has been used in the development of almost all American breeds (Olson, 1982). Development of most of these new breeds included the American Brahman and an European breed. The American Brahman was used as a common denominator in most of these new breeds because most of the new breeds were developed to perform under tropical or semitropical environments. The Santa Gertrudis was the first breed of this kind recognized in the U.S., and was followed by the development of the Brangus, Braford, Beefmaster, Simbrah and other composite breeds.

Most of these newly created breeds are about 3/8 American Brahman and 5/8 of an European breed, the approximate proportions of Brahman and Shorthorn reported for the Santa Gertrudis breed.

Expectations are that a breed originated from a two-breed crossbred foundation will retain half the heterozygosity obtained in the F_1 crossbred, since heterosis appears to be directly related to breed heterozygosity (Warwick and Legates, 1979). Olson et al. (1984), in Florida, concluded that results from the F_2 generation dams did not indicate a loss in productivity greater than the 50 % predicted on a theoretical basis. If heterosis loss from inter se mating is linearly associated with loss of heterozygosity, as theory suggests, then composite breed formation would offer much of the same opportunity as rotational crossbreeding for retaining individual and maternal heterosis (Dickerson, 1973). Crockett et al. (1978a,b) and Olson (1982) agreed in that crossbred populations mated in an inter se system should have performance advantages from retained heterosis approaching those obtainable by systematic crossbreeding. Very little information has been published comparing performance of new breeds with their parental breeds or with the F_1 generation from crossing the parental breeds. A loss of heterosis from the F_1 to the F_2 is likely to occur and has been reported by Meade et al. (1963) for a Brahman x Devon inter se mating system in Florida. On the other hand Olson et al. (1984) found basically no difference in fertility of F_2 cows when compared to F_1 cows in a Brown Swiss x Angus inter se mating system in Florida. In this same study no significant differences were found in birth and weaning weights of calves from the two types of dams.

Isea (1985), working with the same animals as Olson et al. (1984), did not find significant differences in milk yield of F_1 and F_2 dams. In a comprehensive study, Koch et al. (1985) analyzed data from purebred, F_1, backcross, and F_2 and F_3 inter se combinations of Angus and Hereford cattle and estimated the average individual, maternal and grandmaternal genetic effects, individual and maternal heterosis, dominance and epistatic genetic effects. Comparing the F_3 heterosis retention with maximum heterosis, they suggest that epistatic effects may be important for some traits of beef cattle, causing heterosis retention in the F_3 animals to greatly differ from the 50 % expected from purely dominant gene action. The same authors also suggested that heterosis retained in F_3 inter se versus F_1 generation crosses indicated that net epistatic effects were relatively negligible for date of calving, birth weight, weaning weight, and fat cover and that there was a greater reduction of heterosis effects than expected from dominance alone for survival, pregnancy and marbling score. They conclude that except for survival, pregnancy, and marbling the deviations from dominance expectations, or lack of them, are favorable for F_3 composite populations.

STUDY I:
EFFECTS OF BREEDING SEASON ON BEEF COW PRODUCTIVITY

Introduction

The number of calves weaned relative to number of females in the breeding herd and the average calf weight at weaning determine productivity and efficiency of a commercial cow-calf operation. Major losses affecting net calf crop can be attributed to failure of cows to conceive and to calf death at or shortly after birth (Wiltbank et al., 1961). Pregnancy rate and consequent calf crop are directly related to the nutritional and environmental conditions of the cows and calves. Plane of nutrition during the breeding season affects pregnancy rate and consequent calf crop (Warnick, 1963; Preston and Willis, 1970; Peacock et al., 1966; Koger, 1977; Koger et al., 1983a,b). Calf growth, measured as birth weight, preweaning average daily gain (ADG), and weaning weight, is of major importance in determining the overall productivity of a cow-calf operation. Genetic potential of the herd will define the maximum possible growth while environmental factors, especially plane of nutrition, will determine the actual level of expression.

Most commercial cow-calf systems are operated under grazing conditions with native range and cultivated pastures as the main feed sources. The goal of good management should be to make the most intensive and efficient use of available pastures. Establishing a short, fixed breeding season at the correct time of the year permits the matching of quality and quantity of forage available with changes in nutrient requirements of the breeding herd.

Season of birth was found to affect ADG and weaning weight (Minyard and Dinkel, 1965; Franke et al., 1977; Crockett et al., 1978a; Prichard et al., 1982). Cow productivity expressed as kilograms of calf weaned per cow in the breeding herd is the measure which combines both reproductive and growth traits, and is probably the best measure of efficiency of a commercial cow-calf operation (Koger, 1977; Koger et al., 1983a,b).

The purpose of this study was to compare the effects of three breeding seasons on the productivity of a commercial cow-calf system in south Florida.

Experimental Procedure

The present study was conducted from 1978 to 1983 at the Everglades Research and Education Center (AREC), Belle Glade, Florida. The climate in that area of the state is considered semitropical with 75% of rain falling from June through September.

Three breeding seasons were established to compare their effects on productivity of a commercial cow-calf system. Twenty-six first- and second-cross Beefmaster cows were assigned to each of the three breeding groups. The cows were produced in another study at the AREC, and were 2 years of age or older at the time of breeding. The experimental females assigned to each breeding group were balanced at the beginning of the experiment by age. Cows in the three breeding groups were exposed, in single-sire herds, to certified Beefmaster bulls during a 70-day breeding season.

Culling was based on pregnancy status, unsoundnesses and production records. All open and crippled cows were removed, and the lowest producing cows were culled to the extent permitted by the number of replacement heifers. Selection of replacement females was based on weight and condition score at weaning, and postweaning growth rate. Heifers were assigned to the breeding group in which they were produced. Replacement heifers were bred for the first time at 2 years of age to calve at 3 years of age. Cows in each breeding group were palpated for pregnancy about 90 days after the end of their respective breeding seasons. All calves received the same preweaning treatment and were weaned at an average age of 255 days. Each breeding group was maintained throughout the year on 8.1 hectares of Roselawn St. Augustinegrass (Stenotaphrum secundatum [Walt.] Kuntze) pasture grown on 95% organic matter soils. The stocking rate was approximately 3.2 cows per hectare, and grazing was continuous. Pastures were fertilized annually with 336 kg/ha of 0-10-20. All cows were supplemented with cane molasses (IFN 4-04-696) at a rate of 2.04 kg per head/day, for about 100 days during the winter period (November 15 - March 1). When adverse and unusual climatic conditions necessitated the feeding of additional supplement, all groups were treated alike. A complete mineral mix was offered free-choice to all animals throughout the experimental period and parasite control was the same for all groups. Calves were weighed within 24 hours after birth and calves and cows were weighed at weaning.

The experimental design and number of animals are shown in table 1. Data analyzed represented four years (calf crops) and included measures of reproduction, calf survival, birth and weaning weights of

TABLE 1. NUMBER OF COWS BY BREEDING GROUP AND BY BREEDING AND CALVING SEASON DATES

Number of cows	Breeding group	Breeding season	Calving season
26	Early	Nov 1-Jan 10	Aug 10-Oct 19
26	Middle	Jan 1-March 11	Oct 9-Dec 18
26	Late	Feb 15-April 25	Nov 24-Feb 1

calves, and cow weight at the time calves were weaned. Data were analyzed using the General Lineal Model (GLM) procedures of the Statistical Analysis System (SAS), version 1986. Traits included in the analyses were pregnancy, calving, weaning and stillborn rates, calf survival rate from birth to weaning, birth weight, weaning weight, cow weight at weaning and cow productivity. Cow productivity was expressed both as kilograms of calf weaned per cow in the breeding herd and kilograms of calf weaned as a percentage of cow weight in the breeding herd.

The mathematical model used for preliminary analyses included the fixed effects of breeding season, year, sex of calf and age of dam, and their interactions. When the trait involved repeated measurements on the same animal, the random effect of animal (cow) nested within breeding season was included in the model. This random effect was used as the error term to test the main effect of breeding season, and approximate standard errors were estimated for breeding season. After running the complete model, cow and all nonsignificant interactions were dropped from the model and new analyses were performed to obtain the least squares estimates for main and interaction effects. Sex of calf was not included in the model for analyses of reproductive and productivity measures. In a preliminary analysis, sex of calf was tested for its effect on current reproductive status of the dam and was found to have no significant effect. Weaning weights of heifer calves were converted to a steer basis by multiplying the actual weaning weight of females by 1.08. This value was the ratio of the actual weaning weights of steer and heifer calves, which was comparable to 1.07 suggested by the Beef Improvement Federation (B.I.F., 1986).

For the purpose of analysis cows were grouped into three age groups; 3-year-old (pregnancy as 2-yr-olds and productivity as lactating 3-yr-olds), 4-year-old (pregnancy as lactating 3-yr-olds and productivity as 4-yr-old cows nursing their second calf), and 5 years of age and older.

Age of calf at weaning differed among the breeding groups and years due to management decisions; thus, age of calf at weaning (linear, quadratic and cubic) was included in the preliminary analyses of calf weights. Only the linear effect was found to be statistically significant and remained in the final model.

Analyzed calf response traits included birth weight, preweaning average daily gain, weaning weight, stillborn rate and calf survival from birth to weaning. When cow-related traits were analyzed they included pregnancy, calving and weaning rates, pregnancy to calving loss and cow weight at weaning. Herd or combined response traits that were analyzed were kilograms of calf per cow bred (cow productivity) and kilograms of calf as a percentage of cow weight in the breeding herd (cow productivity per cwt).

Results and Discussion

Cow Productivity

Efficiency of the herd is often expressed as kilograms of calf weaned per cow in the breeding herd (cow productivity) and as kilograms of calf weaned as a percentage of weight of cows in the breeding herd (cow productivity per cwt). Cow productivity in a commercial cow-calf operation is the best single measure of herd productivity, since it combines the major determinants of overall efficiency, reproduction and growth, into one value.

Mean cow productivity was 202.6 kg. Koger (1977) reported an average calf production per cow of 203.3 kg from a study on cow-calf systems under three pasture programs in Florida. From another study conducted in Florida, Koger et al. (1983a) reported cow productivity ranging from a low of 210 kg to a high of 232 kg. All of these values closely agree with that found in the present study. Mean productivity per cwt was 38.7%, equal to the the 39% reported by Koger (1977) and higher than the 32% found by Crockett et al. (1978b).

Table 2 shows the least squares means for the two measures of cow productivity and for cow weight by breeding season, year and age group of dam. Breeding season did not affect cow productivity ($P<.40$) or cow productivity per cwt ($P<.52$). Least squares means for the Early, Middle and Late breeding seasons were, respectively, 188.2, 218.0 and 186.6 kg for cow productivity, and 36.4, 43.0 and 36.6% for cow productivity per cwt. Year affected both measures of cow productivity ($P<.002$ and $P<.01$) and also affected almost every trait under study. This finding has been reported for most beef cattle studies conducted under pasture conditions, where climatic variations greatly affect forage production, and thus, nutritional condition of the herd. Year 3 was unusually cold and dry. This was reflected in the large difference found between cow productivity and cow productivity per cwt for Year 3 as compared to those for the remaining years. Cow productivity ranged from a low of 148.3 kg for Year 3 to a high of 219.3 kg for Year 1 (a 48% difference) and cow productivity per cwt ranged from a low of 30.3% to a high of 42.2% (a 40% difference).

TABLE 2. LEAST SQUARES MEANS ± STANDARD ERRORS AND PROBABILITY VALUES (P) FOR COW PRODUCTIVITY, COW WEIGHT, AND COW PRODUCTIVITY PER CWT BY BREEDING SEASON, YEAR, AND AGE GROUP OF DAM

Source of variation	n[a]	Cow productivity, kg	Cow wt, kg	Cow productivity per cwt, %
Arithmetic mean	302 (229)	202.6 ± 6.6	527.8 ± 3.7	38.7 ± 1.3
Breeding season[b]		(P<.40)	(P<.59)	(P<.52)
Early	96 (71)	188.2 ± 18.6	529.3 ± 12.3	36.4 ± 3.6
Middle	106 (83)	218.0 ± 17.7	505.5 ± 11.5	43.0 ± 3.4
Late	100 (75)	186.6 ± 18.2	511.9 ± 12.0	36.6 ± 3.5
Year		(P<.002)	(P<.0001)	(P<.01)
1	79 (62)	219.3 ± 14.7	540.0 ± 8.5	40.5 ± 2.0
2	75 (62)	212.1 ± 17.4	513.4 ± 9.6	42.2 ± 3.3
3	78 (49)	148.3 ± 16.7	498.1 ± 12.5	30.3 ± 3.2
4	70 (56)	210.7 ± 15.7	510.7 ± 9.7	41.7 ± 2.0
Age group of dam		(P<.06)	(P<.0001)	(P<.02)
3-year-old	62 (47)	201.3 ± 8.5	483.1 ± 8.7	42.0 ± 2.9
4-year-old	53 (39)	180.1 ± 14.9	522.1 ± 11.2	35.0 ± 3.2
5 years and older	187 (143)	211.3 ± 8.5	541.5 ± 4.9	39.0 ± 1.6

[a] Values outside parentheses indicate number of observations for cow productivity measures and inside parentheses indicate number of observations for cow weight.

[b] Standard errors for breeding season are approximate.

Cows 5 years of age and older tended (P<.06) to have the highest (211.3 kg) cow productivity, 4-year-old cows the lowest (180.1 kg) and 3-year-old cows were intermediate (201.3 kg). On the other hand the 3-year-old group was the most efficient (P<.02) age group of dam when cow productivity was expressed as a percentage of cow weight (42.0%), followed by cows 5 years of age and older (39%) and the 4-year-old cows (35.0%).

Breeding season by year interactions influenced cow productivity (P<.03) and cow productivity per cwt (P<.01). Figures 1 and 2 show graphically the least squares means for both measures of cow productivity by breeding season and year. The Early breeding season in Year 3 was found to have the lowest values for both measures of cow productivity (96.5 kg and 19.0%, respectively). These significant breeding season x year interaction effects were not unexpected, since it is likely that yearly varying environmental conditions do not always take place at the same time of the year and often are not the same in different years, and consequently, yearly variation will tend to have different effects on different breeding seasons and the resulting calves born in different calving seasons. In this study no breeding season distinctly outproduced any other. In choosing a breeding season for south Florida, therefore, consistency of production over years should be considered, and in this respect the Middle breeding season was the most consistent of the three seasons compared.

Cow Weight

Cow weights were obtained each year on the date calves were weaned. Age of the calf at weaning varied considerably in this study, but this

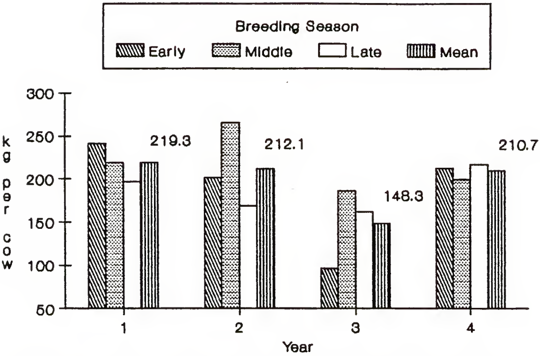

Figure 1. Breeding season x year interaction effects on cow productivity.

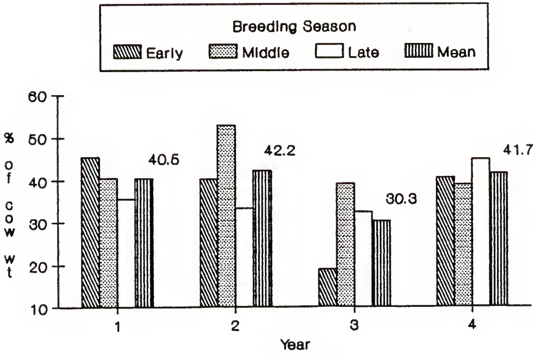

Figure 2. Breeding season x year interaction effects on cow productivity per cwt.

variation in weaning age was due to weaning dates set by management and not to differences among factors studied in this experiment. Cow weights were, therefore, adjusted to a constant age of calf by including calf age as covariate (linear) in the model (P<.02). Mean cow weight was 527.8 kg. Breeding season did not affect (P<.59) cow weight, but year did (P <.0001). Age of dam groups differed in weight (P<.0001) with the youngest group (3-year-olds) having the lightest weight (483.1 kg) and the cows 5 years of age and older having the heaviest (541.1 kg). Breeding season by year (P<.0001) and breeding season by age group of dam (P<.002) interactions affected cow weight (figures 3 and 4). Three-year-old cows in the Early breeding season group were lighter than their counterparts in the other two breeding seasons. The 4-year-old cows and those 5 years and older in the Early breeding season group were the heaviest of all age and breeding season groups, indicating that they were favored by the prevailing environmental (nutritional) conditions up to the time of their corresponding weaning dates. Data on body condition of the different groups at the time they were weighed would have been helpful in explaining the weight differences; however, these data were not recorded for all groups in all years.

Growth Parameters

Calf growth, measured as birth and weaning weights and preweaning average daily gain (ADG), is of major importance in determining the overall productivity of a commercial cow-calf operation. Table 3 shows the least squares means for measurements of calf growth by breeding season, year, age group of dam, and sex of calf.

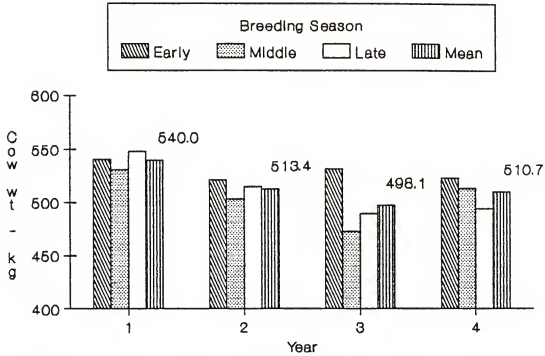

Figure 3. Breeding season x year interaction effects on cow weight.

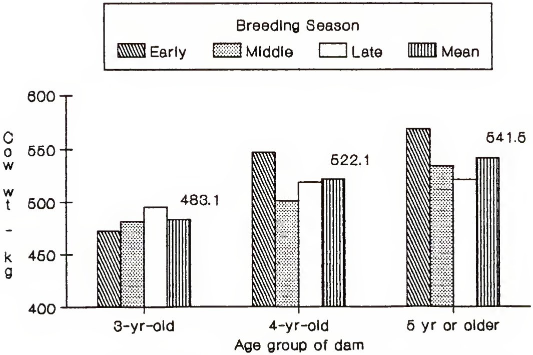

Figure 4. Breeding season x age group of dam interaction effects on cow weight.

TABLE 3. LEAST SQUARES MEANS ± STANDARD ERRORS AND PROBABILITY VALUES (P) FOR CALF BIRTH WEIGHT, WEANING WEIGHT AND PREWEANING AVERAGE DAILY GAIN BY BREEDING SEASON, YEAR, AGE GROUP OF DAM, AND SEX OF CALF

Source of variation	n[a]	Birth weight, kg	Weaning weight, kg	Avg daily gain, kg
Breeding season[b]		(P<.35)	(P<.91)	(P<.92)
Early	73 (71)	31.8 ± .8	252.6 ± 5.1	.862 ± .017
Middle	92 (83)	33.5 ± .7	258.3 ± 4.7	.879 ± .016
Late	84 (75)	33.0 ± .7	246.9 ± 4.9	.844 ± .016
Year		(P<.81)	(P<.0001)	(P<.0001)
1	69 (62)	32.0 ± .6	270.7 ± 3.8	.931 ± .014
2	67 (62)	33.3 ± .7	239.1 ± 4.4	.804 ± .016
3	53 (49)	33.3 ± .9	233.9 ± 5.7	.785 ± .020
4	60 (56)	32.4 ± .6	266.8 ± 4.4	.926 ± .015
Age group of dam		(P<.58)	(P<.12)	(P<.09)
3-year-old	49 (47)	32.3 ± .6	251.8 ± 3.9	.860 ± .010
4-year-old	40 (39)	32.9 ± .8	245.4 ± 5.1	.835 ± .010
5 years and older	160 (143)	33.0 ± .3	260.6 ± 2.2	.891 ± .010
Sex of calf		(P<.03)	(P<.0005)	(P<.0005)
Males	135 (124)	33.6 ± .5	262.0 ± 3.1	.895 ± .011
Females	114 (105)	32.0 ± .5	243.2 ± 3.2	.828 ± .011

[a] Values outside parentheses indicate number of observations for birth weight and inside parentheses indicate number of observations for weaning weight and preweaning ADG.

[b] Standard errors for breeding season are approximate.

Birth weight. Mean birth weight of calves was 32.9 kg. This trait was not affected by breeding season (P<.35), year (P<.81) or age group of dam (P<.58). Vernon et al. (1964), working with crossbred cattle in Louisiana, likewise did not find differences in birth weight due to year. They did, however, report significant differences in birth weight of calves due to season of birth and age of dam. In agreement with reports from many authors (Vernon et al., 1964; Smith et al., 1976; Gregory et al., 1978; Gregory et al., 1979) bull calves in the present study were found to be about 5% heavier at birth than heifer calves. Breeding season x year interactions affected (P<.02) birth weight (figure 5). Variations in pasture quality and quantity in different seasons of the various years probably accounted for the interactions observed, and might be expected if the work were repeated at the same location or even in different regions of the country.

Preweaning ADG and weaning weight. Age of calves at weaning was found to differ (P<.002) among the breeding seasons. These age differences were due to management decisions relative to weaning dates and not true differences in conception dates due to breeding seasons effects. Thus, age of calf at weaning was included as a linear covariate (P<.001) in the model for analysis of weaning weight.

Mean preweaning ADG was .883 kg. Breeding season had no influence (P<.92) on the preweaning growth rate of calves. Weaning weight is made-up of birth weight, ADG from birth to weaning, and weaning age. Since there was no effect of breeding season on birth weight or preweaning ADG, and since adjustments were made for weaning age, it is obvious that weaning weight data should show a pattern similar to that found for ADG (table 3). Mean weaning weight was 258.1 kg, and this

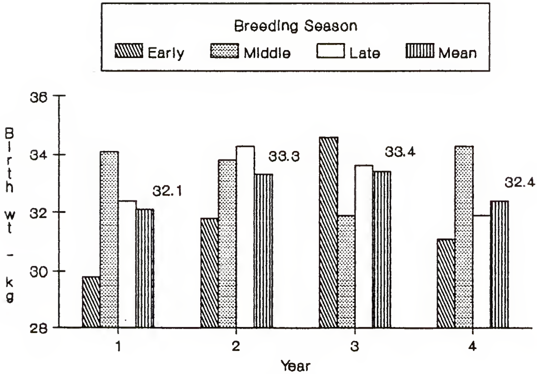

Figure 5. Breeding season x year interaction effects on calf birth weight.

trait was not affected by breeding season (P<.91). Cornwell et al. (1984) likewise did not find a significant difference in performance of fall- and winter-born calves in Florida. Age group of dam tended to affect ADG (P<.09) and weaning weight (P<.12). The lightest average weaning weight (245.4 kg) and lowest preweaning ADG (.835 kg) values were found for the 4-year-old cows. Mature cows tended to wean the heaviest calves with the highest preweaning average daily gain. Many authors have reported differences in ADG and weaning weight due to season of birth and also to age of dam (Minyard and Dinkel, 1965; Franke et al., 1977; Crockett et al., 1978a; Prichard et al., 1982).

In the present study year influenced preweaning ADG (P<.0001) and weaning weight (P<.0001), and bull calves gained faster (P<.0005) and were heavier (P<.0005) at weaning than heifers. Preweaning ADG and weaning weight were both affected by breeding season x year interaction effects (P<.0001) and by the interactions between sex of the calf and year, (P<.02) for preweaning ADG and (P<.01) for weaning weight, as shown in figures 6, 7, 8 and 9. No defined pattern or association of factors could be found for either of these interaction effects.

Reproductive Parameters

Reproductive rate is the trait that has the greatest impact on the overall efficiency of a commercial cow-calf operation. The only measure of reproduction that has real economic value to cattlemen is weaning rate, expressed as the percentage of cows in the breeding herd that wean a calf. Arithmetic and least squares means for the reproductive parameters evaluated in this study are shown in table 4. Breeding season did not affect pregnancy (P<.24), calving (P<.29) or weaning (P<.68) rates. Inspection of the least squares means for the three

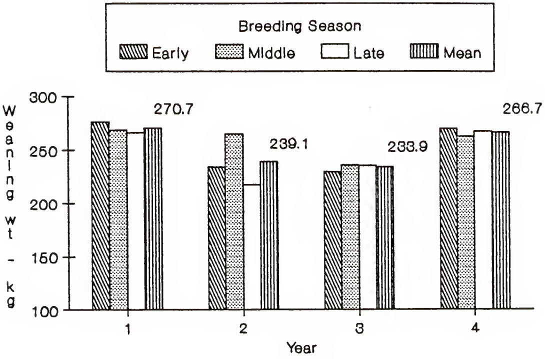

Figure 6. Breeding season x year interaction effects on weaning weight.

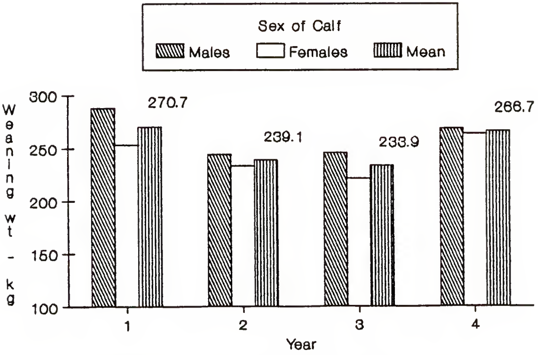

Figure 7. Sex of calf x year interaction effects on age adjusted weaning weight.

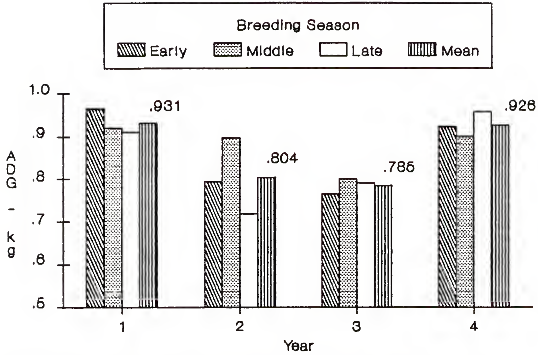

Figure 8. Breeding season x year interaction effects on preweaning average daily gain (ADG) of calves.

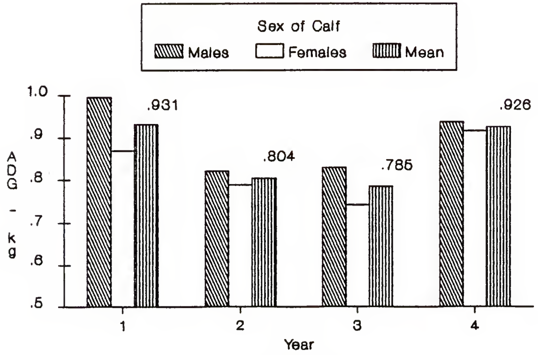

Figure 9. Sex of calf x year interaction effects on preweaning average daily gain (ADG) of calves.

TABLE 4. LEAST SQUARES MEANS ± STANDARD ERRORS AND PROBABILITY VALUES (P) FOR PREGNANCY, CALVING AND WEANING RATES BY BREEDING SEASON, YEAR, AND AGE GROUP OF DAM

Source of variation	n	Rate, %		
		Pregnancy	Calving	Weaning
Arithmetic mean	302	82.4	82.1	76.1
Breeding season[a]		(P<.24)	(P<.29)	(P<.68)
Early	96	71.8 ± 6.0	71.7 ± 6.0	70.0 ± 6.7
Middle	106	86.2 ± 5.7	85.6 ± 5.8	81.2 ± 6.4
Late	100	80.2 ± 5.8	80.1 ± 5.8	73.2 ± 6.6
Year		(P<.0001)	(P<.0001)	(P<.0001)
1	79	84.9 ± 4.6	84.9 ± 4.6	77.3 ± 5.3
2	75	87.4 ± 5.4	87.4 ± 5.5	84.0 ± 6.3
3	78	62.7 ± 5.2	62.6 ± 5.3	59.2 ± 6.0
4	70	82.6 ± 4.9	81.7 ± 4.9	78.8 ± 5.7
Age group of dam		(P<.01)	(P<.02)	(P<.06)
3-year-old	62	78.8 ± 5.3	78.8 ± 4.7	76.3 ± 5.4
4-year-old	54	73.1 ± 4.7	73.1 ± 5.4	70.0 ± 6.7
5 yr and older	186	86.2 ± 2.7	85.7 ± 2.7	78.2 ± 3.1

[a] Standard errors for breeding season are approximate.

breeding seasons compared in this study (November 1 to January 10, January 1 to March 11, and February 15 to April 25) would, however, lead one to choose the Middle season, since the least squares means are the highest for all three traits. Weaning rates observed for all three seasons probably are not optimum. Koger (1977) and Koger et al. (1983a,b) in a 21-year study in Florida, concluded that with good herd management and adequate nutrition it was possible to achieve calf crops of over 90%. However, the observed values compare well to those found by Warnick (1963) and Peacock et al. (1976) in two studies conducted in Florida. A more thorough analysis of the other reproductive traits evaluated in this study should permit one to determine the major causes for the relatively low weaning rates observed.

There is little doubt, after observing values for the reproductive parameters in table 4, that the major factor responsible for the low weaning rate was failure of cows to conceive during the breeding season, or at least be pregnant at the time of pregnancy diagnosis. This is in agreement with Wiltbank et al. (1961), who, in a study where factors affecting net calf crop were analyzed, concluded that major losses in potential calf crop were the results of failure to conceive, early embryonic death, and of calf death at or shortly after birth. Pregnancy rates did not differ ($P<.24$) among breeding seasons. Year affected pregnancy rate ($P<.0001$) and calving rate ($P<.0001$). Losses from pregnancy diagnosis to calving were very low for all years. This indicates that the herd was free from reproductive diseases and also indicates that the pregnancy diagnosis was very accurate.

Four-year-old cows had the lowest reproductive rates. Pregnancy and calving rates were affected (P<.01 and P<.02, respectively) by age group of dam, and there was a tendency (P<.06) for weaning rate to be affected by the same factor. Cows 5 years of age and older had the highest reproductive rates while reproductive rates of the 3-year-olds were intermediate between the 4-year-old and mature cows. The ranking in reproductive efficiency between the 3-year-old and mature cows seems to be in controversy with what is often observed under practical conditions, where the order is generally the opposite. Due to the intensive culling policy for fertility applied to the cow herd, where all open females were culled, cows that were 5 years of age and older were a highly selected population, whereas in most commercial cow-calf operations this rate of culling is seldom practiced. On the other hand, the number of replacement heifers available in this experiment was not large enough to allow a high selection pressure on heifers.

Stillborn and Survival Rates

Least squares means for stillborn and survival rates of calves are shown in table 5. Stillborn rate was calculated as the number of calves born dead as a percentage of the total number of births, and survival rate was calculated as the number of calves weaned as a percentage of the total number of calves born alive. Mean stillborn rate was 3.6 % and mean survival rate of calves was 96.6 %. These values are in close agreement with those reported by Woodward and Clark (1959), Laster and Gregory (1973), Gregory et al. (1978) and Gregory et al. (1979) under different experimental and environmental conditions. Breeding season did not affect stillborn (P<.86) or survival (P<.71) rates. Year affected (P<.02) stillborn rate and tended to affect survival rate

TABLE 5. LEAST SQUARES MEANS ± STANDARD ERRORS AND PROBABILITY VALUES (P) FOR STILLBORN RATE AND SURVIVAL OF CALVES FROM BIRTH TO WEANING BY BREEDING SEASON, YEAR, AND AGE GROUP OF DAM

Source of variation	n[a]	Stillborn rate, %	Survival rate, %
Breeding season[b]		(P<.86)	(P<.71)
Early	73 (71)	.8 ± 3.4	99.7 ± 3.2
Middle	92 (88)	4.6 ± 3.0	96.9 ± 2.9
Late	84 (78)	1.7 ± 3.2	97.2 ± 3.1
Year		(P<.02)	(P<.12)
1	69 (65)	3.7 ± 2.7	95.9 ± 2.6
2	67 (64)	2.0 ± 3.1	98.4 ± 3.0
3	53 (49)	3.4 ± 4.1	100 ± 4.0
4	60 (59)	.3 ± 2.9	96.9 ± 2.8
Age group of dam		(P<.26)	(P<.91)
3-year-old	49 (47)	3.4 ± 2.8	100 ± 2.7
4-year-old	40 (39)	.3 ± 3.7	97.5 ± 3.5
5 years and older	160 (151)	3.9 ± 1.5	95.9 ± 1.5

[a] Values outside parentheses indicate number of observations for stillborn rate and inside parentheses indicate number of observations for survival rate.

[b] Standard errors for breeding season are approximate.

(P<.12). Laster and Gregory (1973), analyzing 5064 parturitions from 1967 to 1972, found no effect of year or season on calf mortality rate. Most of the calves born alive that died, did so within the first 72 hours after birth. This agrees with the reports from Wiltbank et al. (1970) and Reynolds et al. (1980). Age group of dam did not affect stillborn (P<.26) or survival (P<.91) rates. No interactions were found to have significant effects on stillborn or survival rates.

Breeding season, established within the time limits studied and the location where the experiment was conducted, did not significantly affect any of the traits under study. The relatively short period of the year (6 months) covered from the beginning of first to the end of the last breeding season, some overlapping among the breeding seasons, and a reduced climatic variability found in the semitropical region where this study was done, may have contributed to the lack of significant differences due to breeding season. These results would not be found if the experiment were conducted in climatic regions where greater variation in temperature, and thus, greater variations in forage availability and quality, occurred.

No single breeding season of the three compared in the study was superior, although the Middle breeding season, the most commonly used by producers of the area, showed more consistency of production and the least squares means for the production traits tended to be higher than for the other two seasons, and comparable to those of commercial operations. Under the conditions of this experiment the producer can fix his breeding season anywhere within the time limits studied in this experiment, with the exact period he chooses determined by the influence of a series of factors, of which, expected seasonal price variations, how the breeding season and resulting calving season fit into the overall work schedules of the operation, and his personal preference, should be among the most important.

Summary

The effects of breeding season on beef herd productivity in the semitropical environment of south Florida were studied at Everglades Research and Education Center, Belle Glade. Beefmaster cows (n=78) were stratified by age group and allotted to three 70-d breeding seasons (November 1-January 10, January 1-March 11, and February 15-April 25). Each cow remained in her assigned breeding season for the 4-year duration of this study. Each herd was continuosly grazed on 8.1 ha of Roselawn St. Augustinegrass pasture grown on organic soil and supplemented with 2.04 kg of cane molasses head^{-1} d^{-1} from about November 15 to March 1. Response variables included pregnancy, calving, calf survival and weaning rates, calf birth and weaning weights and cow productivity. Breeding season did not significantly affect any of the response variables. Year did affect ($P<.05$) all response variables except calf birth weight and survival rate. Breeding season by year interactions affected calf weaning weight, cow weight ($P<.0001$) and cow productivity ($P<.01$). These data indicate that a satisfactory breeding season could be established at any time within the interval studied, and herd management adjusted to minimize yearly variations. Age of dam affected pregnancy rate ($P<.01$), calving rate ($P<.01$), weaning rate ($P<.06$), and cow productivity ($P<.06$).

STUDY II:
COMPARISONS OF TWO BRAHMAN-ANGUS CROSSBRED GROUPS IN INTER SE MATING PROGRAMS

Introduction

Differences in mean gene frequencies, average heterozygosity, and epistatic combination effects determine genetic diversity among breeds (Dickerson, 1973). Selection, combined with grading-up to superior breeds, heterosis from crossbreeding, and development of new breeds are the basic ways to take advantage of genetic diversity for improvement of beef cattle production (Dickerson, 1969). The humid tropics and semitropics offer a great potential for beef production, but many of the same climatic factors responsible for this potential also negatively affect performance of nonadapted cattle. The basic requirements for beef cattle in the tropics are distinctly foreign to the improved European breeds (Koger, 1973). Exploitation of hybrid vigor through systematic crossbreeding appears to be an effective, quick way to improve productivity and level of efficiency in commercial cattle operations (Cundiff, 1970,1977; Gregory and Cundiff, 1980; Long, 1980). Crockett et al. (1978a,b) and Peacock and Koger (1980) reported that Zebu-European crossbreds outperformed European-European crossbreds under the climatic conditions of south and central Florida. Systematic, rotational crossbreeding programs are not accessible to many producers throughout the U.S.A. and the world, due to managerial and herd size constraints. The use of composite breeds or of crossbred cows and bulls in an inter se mating scheme appears as a valid alternative for exploiting the benefits from heterosis without the practical restrictions of a rotational crossbreeding program. A new breed originated from a two-breed foundation should retain half the heterozygosity and, as heterosis appears to be directly related to breed heterozygosity, should retain one half of the heterosis of the foundation F_1 cross (Preston and Willis, 1970; Warwick and Legates, 1979). Retained heterosis level in an inter se mating program of a synthetic breed or of crossbreds should compare favorably with that retained in a rotational crossbreeding program using the same two breeds. Very little information has been published comparing actual level of performance of new breeds with their parental breeds or their F_1 crosses, and no data were found comparing performance of inter se mated composite groups varying only in percentage composition of the same parental breeds.

The purpose of this study was to compare the productivity of 3/8 Brahman:5/8 Angus (Brangus) and of 1/2 Brahman:1/2 Angus inter se mated populations in a cow-calf system in south Florida.

Experimental Procedure

This experiment was designed primarily to compare the performance of two Brahman-Angus crossbred populations mated inter se. The two populations were 3/8 Brahman:5/8 Angus (Brangus) and 1/2 Brahman:1/2 Angus (F_1BA). The study was conducted at the Everglades Research and Education Center (EREC), Belle Glade, Florida. The climate is considered semitropical, with a distinct dry season.

The Brangus and F_1BA cows used to initiate this study were produced at the EREC. The F_1BA cows were all from Angus cows and were sired by Brahman bulls. The numbers of breeding females by year and the mating schemes used are shown in table 6. Heifers were put into the breeding herd at 2 years of age, to calve first as 3-yr-olds. Selected heifers produced in the Brangus inter se group were retained in the group to maintain numbers. Heifers produced in the F_1BA mating group likewise were retained as breed replacements for that group. These females are shown as F_2 Brahman x Angus (F_2BA) in table 6.

A 70-day breeding season started about January 1 each year. During the breeding season the cows were separated and the Brangus cows bred to Brangus bulls and the F_1 and F_2BA cows bred to F_1BA bulls. Three bulls of each breed type were used, in single-sired herds, at least 3 consecutive years. Bulls (within each breed group) were rotated among supplementation treatments (described below) so that each bull was used in all treatments. Bulls were obtained from unrelated herds in Florida and Texas. All cows were palpated for pregnancy about 90 days after the end of the breeding season. Open and crippled cows were culled from the herd, and low producing cows were culled to the extent permitted by available replacement heifers. Replacement heifers were selected on weaning weight and condition score, post-weaning growth, and soundness.

The females used in the experiment were also utilized during the first 5 years in a study on molasses supplementation. The Brangus and F_1BA cows were randomly assigned, within breed group, to three molasses supplementation treatments: (1) no molasses supplementation; (2) 85-day molasses supplementation, from December 15 to the end of the breeding season; and (3) 145-day molasses supplementation, from October

TABLE 6. NUMBER OF BREEDING FEMALES PER YEAR BY BREED GROUP OF COW AND BULL

Breed group of cow	Breed group of bull	Year[a] 1	2	3	4	5	6	Total
Brangus	Brangus	61	61	62	71	59	62	376
F_1 (Brahman x Angus)	F_1 (Brahman x Angus)	62	62	51	47	40	33	295
F_2 (Brahman x Angus)	F_1 (Brahman x Angus)			11	15	26	28	80
Total		123	123	124	133	125	123	751

[a] Years 1 through 6 correspond to 1978 through 1983.

15 to the end of the breeding season. Each molasses supplementation group was composed of about equal numbers of Brangus and F_1BA cows. The cows in each molasses supplementation-breed group were assigned to a weaning age study where half of the calves were weaned at about 8.5 months of age and the other half weaned at an average age of about 10.5 months. Weaning date effect was not considered in the analyses of the present study since the weight at about 8.5 months of age was used for all calves and since Pate et al. (1985), reporting on the weaning date, showed that weaning age did not significantly affect cow reproduction or performance.

Cows were grazed year-round on Roselawn St. Augustinegrass (Stenotaphrum secundatum [Walt.] Kuntze) pastures grown on an organic soil (sawgrass peat, 95% organic matter) at a stocking rate of about 3.1 animal units per hectare. All pastures were fertilized annually with 336 kg of 0-10-20 (N-P-K) per hectare. A mineral mix (20% NaCl, 13% Ca, 8% P, .8% Cu, .6% Fe and .03% Co) and water were always available for all cattle. The two supplemented groups were fed 2.25 kg per head daily of blackstrap cane molasses (IFN 4-04-696) during their respective supplementation periods.

Calves were weighed at birth and at the weaning date of the first weaning group, about 8.5 months of age, and cow weight was recorded at this latter time. Bull calves were castrated at birth.

Data were analyzed using the General Linear Model (GLM) procedures of the Statistical Analysis System (SAS), version 1986, and Harveys Mixed Model Least-Squares and Maximum Likelihood Computer Program, version 1987. Analyses for all traits were performed by the method of ordinary least-squares analysis of variance. A preliminary analysis was performed to determine possible molasses treatment effects, and as no significant effects or interactions were detected, molasses treatment was dropped from the final mathematical models.

Complete final mathematical models used for the analyses included the fixed main and interaction effects of breed and year for reproductive traits and cow productivity. The mathematical models for analyses of cow weight, survival, birth weight, preweaning average daily gain (ADG) and weaning weight included the fixed main and interaction effects of breed, year and sex of calf. The random effect of cow (animal) nested within breed group, included in all the mathematical models for analysis of variance, was used as error term to test for significance of main effect of breed group. To obtain the least squares estimates for main effects and for interactions of interest the random effect of animal nested within breed was dropped from the mathematical models and other analyses performed, thus, calculated standard errors were approximate.

Sex of calf was not included in the analyses for cow reproductive and productivity traits. In a complementary analysis the effect of sex of nursing calf on the rebreeding performance of the dam was tested, and no significant effect was found. All cow productivity data were converted to a steer basis by multiplying values for heifer calves by a factor of 1.07, suggested for use in Brangus cattle conversions by the International Brangus Breeders Association and by the Beef Improvement Federation (B.I.F., 1986). Age of dam within the two breed groups was very unbalanced at the beginning of the experiment. The average age of the Brangus at the beginning of the first breeding season was 9.2 years and for the F_1BA was 2.5 years. As no satisfactory procedure to include age of dam in the model was found, and in order to avoid possible bias due to this factor, all calf performance measures (i.e. calf birth and weaning weights and preweaning ADG) were adjusted to a mature dam equivalent. The correction coefficients used for this purpose were those suggested by the American Beef Improvement Federation (BIF, 1986) used by the International Brangus Breeders Association.

For the purpose of a better interpretation and discussion of the results of the present study, three analyses were performed for every response variable under evaluation. In the first, comparisons were made between the two inter se mating groups, that is, 3/8 B:5/8 A (Brangus) and the 1/2 B:1/2 A crossbreds (F_1 + F_2). Comparisons of the Brangus and F_1BA cows were made in the second analysis. In the third, comparisons were made among the three types of cows (Brangus, F_1BA, and F_2BA). Only data from the last 4 years of the study were used in the last analysis, since these years had all three groups of cows represented.

Results and Discussion

Comparison Between Inter Se Mating Groups (3/8 B:5/8 A vs 1/2 B: 1/2 A)

Year and sex of calf affected ($P<.01$) almost every trait included in this study. Yearly variations of environmental conditions affect most performance traits and male calves are heavier and have higher potential for growth than females (Preston and Willis, 1970; Rovira, 1972; Smith et al., 1976; Gregory et al., 1978; Gregory et al., 1979). Since the year and sex of calf effects observed in this study were to be expected and since these findings do not make new contributions to the scientific literature, these effects will only be discussed when they are of importance to the present study.

Cow productivity

Cow productivity, expressed as kilograms of calf weaned per cow in the breeding herd (cow productivity) and as kilograms of calf weaned as a percentage of weight of cows in the breeding herd (cow productivity per cwt), is commonly used to evaluate productivity of a beef herd (Koger, 1977; Crockett et al., 1978b). Cow productivity is the product of average weaning weight x weaning rate, thus is the trait that combines the two factors that have the greatest impact on level of production. Cow productivity per cwt has the added feature that it expresses production as a percentage of cow weight, and is therefore, a good indicator of efficiency of production.

Mean cow productivity and cow productivity per cwt were 180.5 kg and 39.7%, respectively, for the two inter se mating groups combined. Cow productivity of the 1/2 B:1/2 A inter se mating group was higher ($P<.03$) than that of the 3/8 B:5/8 A group (197.1 vs 165.3 kg) (table 7). Cows from the 1/2 B:1/2 A mating group were heavier ($P<.001$) than cows from the 3/8 B:5/8 A group, and when cow productivity was expressed as a percentage of cow weight, differences between the two inter se mating groups tended ($P<.13$) to be significant, 42.4% for the 1/2 B:1/2 A versus 37.1% for the 3/8 B:5/8 A (table 7). These cow productivity values are comparable to those found in Florida by Koger et al. (1983a,b). Significant inter se mating group by year interactions affected ($P<.0001$) cow productivity and cow productivity per cwt (table 8). The 1/2 B:1/2 A group was superior in all years, except for Year 1978, and this superiority reached a high, in 1980, of 61.3 kg for cow productivity, and 11% for cow productivity per cwt.

TABLE 7. LEAST SQUARES MEANS ± APPROXIMATE STANDARD ERRORS AND PROBABILITY VALUES (P) FOR COW PRODUCTIVITY, CALF PERFORMANCE, REPRODUCTION AND CALF SURVIVAL TRAITS BY INTER SE BREEDING GROUP

		Inter se breeding group			
Source of variation	P values	n	3/8 B:5/8 A	n	1/2 B:1/2 A
Cow productivity traits					
Cow productivity, kg	.03	376	165.3 ± 8.8	375	197.1 ± 8.9
Cow productivity per cwt, %	.13	376	37.1 ± 2.7	375	42.4 ± 2.7
Cow weight, kg	.001	259	446.2 ± 6.3	285	469.9 ± 6.0
Calf performance traits					
Birth wt, kg	.0001	290	27.9 ± .4	321	31.6 ± .3
Preweaning ADG, kg	.0001	267	.761 ± .007	294	.838 ± .007
Weaning wt, kg	.0001	267	224.3 ± 2.2	294	244.3 ± 2.1
Weaning age, d	.01	267	258.0 ± 1.2	294	254.0 ± 1.1
Reproduction traits		376		375	
Pregnancy, %	.10		81.2 ± 3.1		86.9 ± 3.1
Calving, %	.01		76.9 ± 3.2		85.5 ± 3.2
Weaning, %	.05		71.2 ± 3.5		78.6 ± 3.5
Calf survival traits		290		321	
Stillborn, %	.15		3.5 ± 1.9		5.1 ± 1.8
Mortality					
Day 0 to 4, %	.81		1.5 ± .9		1.3 ± .9
Day 4 to weaning, %	.46		2.5 ± 1.2		1.8 ± 1.1
Survival, %	.11		92.5 ± 2.3		91.7 ± 2.2

TABLE 8. LEAST SQUARES MEANS ± STANDARD ERRORS FOR COW PRODUCTIVITY MEASURES BY INTER SE BREEDING GROUP AND YEAR

	Inter se breeding group[a]			
	3/8 B:5/8 A		1/2 B:1/2 A	
	Cow productivity		Cow productivity	
Year	Kg	Per cwt, %	Kg	Per cwt, %
1978	163.9 ± 13.6	34.9 ± 3.1	158.3 ± 13.6	33.9 ± 3.1
1979	185.1 ± 13.7	42.7 ± 3.1	212.1 ± 13.6	46.4 ± 3.1
1980	163.2 ± 13.6	39.2 ± 3.1	224.5 ± 13.6	50.2 ± 3.1
1981	124.7 ± 12.7	31.1 ± 2.9	178.4 ± 13.6	40.3 ± 3.0
1982	193.7 ± 13.9	41.5 ± 3.1	197.2 ± 13.1	43.0 ± 3.1
1983	161.0 ± 13.6	31.6 ± 3.2	212.2 ± 13.7	42.1 ± 3.2

[a] Interactions between breeding group and year affected ($P<.0001$) cow productivity and cow productivity per cwt.

Calf performance

Average birth weight of calves from the 1/2 B:1/2 A group was heavier (P<.0001) than for the 3/8 B:5/8 A group, with calves from the 1/2 B:1/2 A inter se mating group about 13% heavier at birth than the 3/8 B:5/8 A calves (31.6 and 27.9 kg, respectively).

Mean weaning weight for the two groups was 233.5 kg. Calves from the 1/2 B:1/2 A inter se mating group were about 20 kg heavier (P<.0001) at weaning and had greater (P<.0001) ADG from birth to weaning than those from the 3/8 B:5/8 A inter se group (table 7). Inter se mating group by year interactions affected (P<.0001) weaning weight and ADG (table 9). Calves from the 1/2 B:1/2 A breeding group were heavier at weaning and had higher ADG in all years than those from the 3/8 B:5/8 A breeding group. Maximum and minimum weaning weight advantages for the 1/2 B:1/2A group among years were 37.8 and 2.5 kg, respectively.

Breed differences for age at weaning were due to differences in gestation length and time of conception within the breeding season. Calves born earlier in the calving season, other things being equal, will be heavier at weaning. Age at weaning in the present study was evaluated as a calf performance trait. Mean age at weaning for the two inter se mating groups combined was 256 days. The 3/8 B:5/8 A calves were older (P<.01) than calves from the 1/2 B:1/2 A group (table 7). The difference in age at weaning would indicate that 3/8 B:5/8 A cows either conceived earlier in the breeding season or had a shorter average gestation length than the 1/2 B:1/2 A cows. Average gestation length of Brahman cows is longer than the average gestation length of Angus (Preston and Willis, 1970). The 1/2 B:1/2 A cows have 1/8 more Brahman

TABLE 9. LEAST SQUARES MEANS ± STANDARD ERRORS FOR WEANING WEIGHT AND PREWEANING AVERAGE DAILY GAIN (ADG) OF CALVES BY INTER SE BREEDING GROUP AND YEAR

	Inter se breeding group[a]			
	3/8 B:5/8 A		1/2 B:1/2 A	
Year	Weaning wt, kg	Preweaning ADG, kg	Weaning wt, kg	Preweaning ADG, kg
1978	242.5 ± 4.5	.838 ± .01	263.2 ± 4.7	.918 ± .01
1979	227.5 ± 4.1	.772 ± .01	254.2 ± 4.0	.871 ± .01
1980	202.7 ± 4.2	.676 ± .01	240.5 ± 3.8	.812 ± .01
1981	190.5 ± 4.3	.620 ± .01	214.0 ± 4.0	.718 ± .01
1982	235.0 ± 4.2	.805 ± 01	237.5 ± 3.9	.815 ± .01
1983	247.5 ± 4.5	.858 ± .01	256.1 ± 4.2	.898 ± .01

[a] Interactions between breeding group and year affected (P<.0001) weaning weight and preweaning average daily gain (ADG) of calves.

and 1/8 less Angus component in their genotype than the 3/8 B:5/8 A cows, thus, the additive breed effects on cow gestation length may have been partly responsible for the differences found in age of the calves at weaning.

Reproductive behavior

Mean pregnancy, calving and weaning rates, for the two groups combined, were 84.1, 81.2 and 74.8%, respectively. The 1/2 B:1/2 A inter se mating group tended ($P<.10$) to have a higher pregnancy rate, and did have higher calving ($P<.01$) and weaning ($P<.05$) rates (table 7). Mating group by year interaction effects ($P<.0001$) were found for the three reproduction parameters (table 10). The average reproduction rate, measured as pregnancy, calving or weaning rate, of cows from the 1/2 B:1/2 A mating group was superior to that of cows from the 3/8 B:5/8 A mating group in all years, except for 1978.

Mean stillborn rate and rate of survival from birth to weaning were 4.4 and 92.1%, respectively. Stillborn rate from the two inter se mating groups did not differ ($P<.15$), although stillbirth incidence in the 1/2 B:1/2 A mating group tended to be greater (table 7). The larger birth weight of calves from the 1/2 B:1/2 A mating group may have been a factor responsible, at least in part, for the observed stillborn rate. Survival from birth to weaning was quite similar for the two inter se mating groups. Least squares means for survival rate, were 92.5 and 91.7%, respectively, for the 3/8 B:5/8 A and the 1/2 B:1/2 A groups. These survival rates are lower than the 96% observed in other studies which were conducted with different breed groups and under different conditions (Woodward and Clark, 1959; Gregory et al., 1978; Gregory et al., 1979). Mortality rates from day 0 to 4 and day 4 to weaning

TABLE 10. LEAST SQUARES MEANS ± STANDARD ERRORS FOR PREGNANCY, CALVING, AND WEANING RATES BY INTER SE BREEDING GROUP AND YEAR

	Reproduction parameter, %		
Year and inter se breeding group[a]	Pregnancy	Calving	Weaning
1978			
3/8 B:5/8 A	75.2 ± 4.6	68.8 ± 4.8	65.5 ± 5.4
1/2 B:1/2 A	71.0 ± 4.5	66.1 ± 4.8	58.0 ± 5.4
1979			
3/8 B:5/8 A	85.0 ± 4.6	83.6 ± 4.8	78.6 ± 5.4
1/2 B:1/2 A	85.6 ± 4.5	85.4 ± 4.8	82.1 ± 5.4
1980			
3/8 B:5/8 A	90.3 ± 4.5	90.3 ± 4.8	77.4 ± 5.8
1/2 B:1/2 A	95.1 ± 4.7	95.1 ± 4.8	90.3 ± 5.6
1981			
3/8 B:5/8 A	85.6 ± 4.3	73.2 ± 4.6	63.3 ± 5.1
1/2 B:1/2 A	92.0 ± 4.6	91.9 ± 4.8	80.6 ± 5.4
1982			
3/8 B:5/8 A	81.3 ± 4.6	81.3 ± 4.9	79.6 ± 5.5
1/2 B:1/2 A	87.8 ± 4.4	87.8 ± 4.6	80.3 ± 5.3
1983			
3/8 B:5/8 A	69.3 ± 4.5	64.5 ± 4.8	62.9 ± 5.4
1/2 B:5/8 A	90.1 ± 4.6	86.8 ± 4.8	80.3 ± 5.4

[a] Interactions between breeding group and year affected ($P<.0001$) pregnancy, calving and weaning rates.

did not differ ($P<.81$ and $P<.46$, respectively) between the two mating programs.

Comparisons between the two inter se mating groups tended to show superior overall performance for the 1/2 B:1/2 A mating group. However, the 3/8 B:5/8 A population had been inter se mated for some generations prior to the initiation of this experiment, while the 1/2 B:1/2 A population had been recently created and many of the cows were true F_1. The females of the 1/2 B:1/2 A breed group were separated into F_1 and F_2 groups, and comparisons among the breed groups (3/8 B:5/8 A, F_1BA, and F_2BA) from the two inter se mated populations were performed, and an additional analysis was made comparing the 3/8 B:5/8 A and the F_1BA.

Comparison Among Cow Breed Groups

Brangus versus F_1 Brahman x Angus (F_1BA)

Least squares means for cow productivity, reproduction, calf performance, and calf survival traits for the Brangus and F_1BA breed groups are presented in table 11.

The F_1BA cows had higher cow productivity ($P<.0001$) (211.1 vs 165.3 kg) and were more efficient ($P<.003$) than Brangus cows when efficiency of production was expressed as calf weight at weaning as a percentage of cow weight (44.5 vs 37.1%). Cow weight differed ($P<.0001$) between the two breed groups, with the F_1BA cows averaging about 34 kg heavier than Brangus cows (445.8 vs 479.5 kg). Cow breed group by year interactions affected ($P<.0001$) cow productivity and cow productivity per cwt (table 12). The maximum difference in cow productivity, favorable to the F_1BA cows, was about 53% for both productivity measures. In 1978, however, productivity of the Brangus cows was

TABLE 11. LEAST SQUARES MEANS ± APPROXIMATE STANDARD ERRORS AND PROBABILITY VALUES (P) FOR COW PRODUCTIVITY,CALF PERFORMANCE, REPRODUCTION AND CALF SURVIVAL TRAITS BY COW BREED GROUP

		Cow breed group			
Source of variation	P values	n	Brangus	n	F_1 BA
Cow productivity traits					
Cow productivity, kg	.0001	376	165.3 ± 8.8	295	211.1 ± 9.8
Cow productivity per cwt, %	.003	376	37.1 ± 2.7	295	44.5 ± 2.3
Cow weight, kg	.0001	259	445.8 ± 6.3	234	479.5 ± 6.6
Calf performance traits					
Birth wt, kg	.0001	290	27.9 ± .4	259	31.4 ± .5
Preweaning ADG, kg	.0001	267	.761 ± .007	241	.841 ± .009
Weaning wt, kg	.0001	267	224.3 ± 2.2	241	245.8 ± 2.9
Weaning age, d	.06	267	258.0 ± 1.2	241	255.0 ± 1.6
Reproduction traits		376		295	
Pregnancy, %	.009		81.2 ± 3.1		91.0 ± 3.4
Calving, %	.001		76.9 ± 3.2		89.7 ± 3.6
Weaning, %	.002		71.2 ± 3.5		83.8 ± 3.9
Calf survival traits		290		259	
Stillborn, %	.85		3.5 ± 1.9		3.9 ± 2.1
Mortality					
Day 0 to 4, %	.75		1.5 ± .9		1.2 ± .9
Day 4 to weaning, %	.36		2.5 ± 1.2		1.3 ± 1.2
Survival, %	.72		92.5 ± 2.3		93.5 ± 2.4

TABLE 12. LEAST SQUARES MEANS ± STANDARD ERRORS FOR COW PRODUCTIVITY MEASURES BY COW BREED GROUP AND YEAR

	Cow breed group[a]			
	Brangus		F1 BA	
	Cow productivity		Cow productivity	
Year	Kg	Per cwt, %	Kg	Per cwt, %
1978	163.9 ± 13.6	34.9 ± 3.1	158.3 ± 13.6	33.9 ± 3.1
1979	185.1 ± 13.7	42.7 ± 3.1	212.1 ± 13.6	46.4 ± 3.1
1980	163.2 ± 13.6	39.2 ± 3.1	234.1 ± 14.6	50.4 ± 3.4
1981	124.7 ± 12.3	31.1 ± 2.9	198.6 ± 15.1	43.4 ± 3.4
1982	193.7 ± 13.9	41.5 ± 3.1	215.4 ± 16.4	44.6 ± 3.9
1983	161.0 ± 13.6	31.6 ± 3.2	247.8 ± 18.1	42.1 ± 3.2

[a] Interactions between cow breed group and year affected (P<.0001) cow productivity and cow productivity per cwt.

about 3% higher than that of the F_1BA cows. This may have been the result of the extreme imbalance in age of the two groups of dams at the beginning of the experiment. The F_1BA cows averaged 2.5 years of age when the experiment began, while the Brangus cows averaged 9.2 years of age.

Birth weight, preweaning ADG, and weaning weight comparisons showed superior performance for calves from F_1BA cows. Similar superiorities for calves from F_1 dams have been reported by other researchers (Cundiff, 1970; Koger et al., 1973; Cundiff, 1977). The F_2BA calves produced from inter se mating of F_1BA bulls and cows weighed more at birth ($P<.0001$) and at weaning ($P<.0001$), and had a faster preweaning average daily gain ($P<.0001$) than calves from Brangus dams. The F_2BA calves were 21.5 kg (9%) heavier at weaning and gained .08 kg more per day (+10.5%) than the Brangus calves. The Brangus calves tended ($P<.06$) to be older than the F_2BA calves. Despite this age advantage found for the Brangus calves, their average weight at weaning was lighter than that of the F_2BA calves (245.8 vs 224.3 kg, respectively). Cow breed group by year interactions affected ($P<.001$) preweaning ADG. The F_2BA calves had higher preweaning ADG in all years with their advantage ranging from a high of .159 kg, in 1980, to a low of .012 kg per day, in 1982, (table 13).

The F_1BA cows had higher average pregnancy ($P<.009$), calving ($P<.001$), and weaning ($P<.002$) rates than Brangus cows. This superiority was about 12.1, 16.6 and 17.6%, respectively, for the three reproductive parameters. Higher reproductive performance for F_1 crossbred cows has been reported by several authors (Cundiff, 1970; Preston and Willis, 1970; Koger et al., 1973). Differences between the

TABLE 13. LEAST SQUARES MEANS ± STANDARD ERRORS FOR PREWEANING AVERAGE DAILY GAIN (ADG) OF CALVES BY COW BREED GROUP AND YEAR

	Cow breed group[a]	
	Brangus	F_1 BA
Year	ADG, kg	ADG, kg
1978	.838 ± .01	.918 ± .01
1979	.772 ± .01	.871 ± .01
1980	.674 ± .01	.833 ± .01
1981	.619 ± .01	.713 ± .01
1982	.804 ± .01	.816 ± .01
1983	.858 ± .01	.895 ± .01

[a] Interactions between cow breed group and year affected (P<.001) preweaning average daily gain (ADG).

Brangus and the F_1BA cow breed groups for stillborn rate (P<.85), calf mortality rate from day 0 to 4 (P<.75) and from day 4 to weaning (P<.36), and calf survival rate (P<.72) were very small.

Brangus vs F_1BA vs F_2BA comparison

Least squares means for cow productivity and reproduction, and for calf performance and survival traits are shown in table 14, for the Brangus, F_1BA and F_2BA breed groups of cows. Data from the last 4 years of the experiment were utilized for this comparison, as all three breed groups of cows were represented in those years. Cow productivity (P<.0001) and cow productivity per cwt (P<.004) were higher for the F_1BA than for the F_2BA and Brangus cows. The two latter cow breed groups did not differ in either measure of productivity. Cow breed group by year interactions affected both productivity measures (P<.0001) (table 15). It would appear that F_1BA cows had less year to year variation in productivity. This would reflect a more stable overall performance of the F_1BA cows in response to varying environmental conditions. However, the values for productivity of the F_2BA, except for 1981, were relatively stable. In 1981 most of the F_2BA were 3 years of age nursing their first calf, and most research has shown that cows in this category generally have the lowest conception rate of all age groups in the herd. Nevertheless, the stability in productivity of the F_2BA cows was in the vicinity of lower values than those of the F_1BA cows. Cow weights differed (P<.0001) among the three types of cows, with ranking of cow weights in descending order of F_1BA (485.8 kg), Brangus (440.7 kg), and F_2BA (421.6 kg).

TABLE 14. LEAST SQUARES MEANS ± APPROXIMATE STANDARD ERRORS AND PROBABILITY VALUES (P) FOR COW PRODUCTIVITY, CALF PERFORMANCE, REPRODUCTION AND CALF SURVIVAL TRAITS BY COW BREED GROUP

		Cow breed group					
Source of variation	P values	n	Brangus	n	F_1 BA	n	F_2 BA
Cow productivity traits							
Cow productivity, kg	.0001	254	160.6 ± 9.5	171	224.0 ± 11.6	80	158.4 ± 16.9
Cow productivity per cwt, %	.004	254	36.2 ± 2.1	171	46.7 ± 2.6	80	37.9 ± 3.7
Cow weight, kg	.0001	171	440.7 ± 6.7	149	485.8 ± 7.2	51	421.6 ± 12.3
Calf performance traits							
Birth wt, kg	.0001	196	27.7 ± .6	165	31.4 ± .6	62	32.3 ± 1.0
Preweaning ADG, kg	.0001	179	.739 ± .011	155	.814 ± .012	53	.786 ± .020
Weaning wt, kg	.0003	179	218.7 ± 3.1	155	239.1 ± 3.3	53	226.2 ± 5.7
Weaning age, d	.003	179	259.0 ± 1.7	155	255.0 ± 1.8	53	248.0 ± 3.1
Reproduction traits		254		171		80	
Pregnancy, %	.0007		81.7 ± 3.3		97.4 ± 4.0		81.9 ± 5.9
Calving, %	.0001		77.3 ± 3.5		96.7 ± 4.2		81.0 ± 6.2
Weaning, %	.0002		70.8 ± 3.9		90.7 ± 4.8		67.1 ± 7.8
Calf survival traits		196		165		62	
Stillborn, %	.21		4.8 ± 2.4		3.3 ± 2.6		11.0 ± 4.2
Mortality							
Day 0 to 4, %	.85		.6 ± 1.1		1.2 ± 1.2		2.1 ± 1.9
Day 4 to weaning, %	.59		3.1 ± 1.7		1.3 ± 1.9		5.6 ± 3.0
Survival, %	.08		91.6 ± 2.9		94.0 ± 3.2		82.1 ± 5.2

TABLE 15. LEAST SQUARES MEANS ± STANDARD ERRORS FOR COW PRODUCTIVITY AND COW PRODUCTIVITY PER CWT BY COW BREED GROUP AND YEAR

Year	Cow breed group[a]		
	Brangus	F_1 BA	F_2 BA
1980			
Cow productivity, kg	163.2 ± 12.6	234.1 ± 13.8	179.6 ± 29.8
Cow productivity per cwt, %	39.2 ± 2.8	50.4 ± 3.3	49.4 ± 6.9
1981			
Cow productivity, kg	124.7 ± 11.7	198.7 ± 14.4	114.8 ± 25.5
Cow productivity per cwt, %	31.1 ± 2.8	43.4 ± 3.4	30.6 ± 6.0
1982			
Cow productivity, kg	193.7 ± 12.9	215.4 ± 15.6	169.1 ± 19.4
Cow productivity per cwt, %	42.9 ± 3.0	44.5 ± 3.7	36.7 ± 4.7
1983			
Cow productivity, kg	161.0 ± 12.6	247.8 ± 17.2	170.2 ± 18.7
Cow productivity per cwt, %	31.6 ± 3.1	48.5 ± 4.2	35.2 ± 4.4

[a] Interactions between cow breed group and year affected ($P<.0001$) cow productivity and cow productivity per cwt.

Birth weight of calves from the different cow breed groups differed ($P<.0001$). Calves from F_1BA and F_2BA crossbred dams were heavier at birth than calves from Brangus dams (31.4, 32.3, and 27.7 kg respectively) and calves from F_2BA cows were slightly heavier at birth than calves from F_1BA dams. This is in agreement with Olson et al. (1984), who found no difference in birth weights when comparing calves from F_1 and F_2 cows in a Brown Swiss x Angus inter se mating system in Florida. Weaning weight of calves from F_1BA cows was heavier ($P<.0003$) than that of calves from Brangus and F_2BA cows. This finding is in disagreement with Olson et al. (1984), who did not find differences in weaning weights of calves from F_1 and F_2 dams. Preweaning ADG of calves differed ($P<.0001$), with cow breed groups ranked in the order of F_1BA, F_2BA and Brangus. Cow breed group x year interactions affected weaning weight ($P<.0009$) and preweaning ADG ($P<.001$) of calves (table 16). Weaning weights of calves from F_1BA cows were always the heaviest, those of calves from F_2BA cows were intermediate, and weaning weights of calves from Brangus dams ranked the lightest. Calves from F_2BA cows were the youngest at the date of weaning and their average age was 7 and 11 days less than the average age of calves from F_1BA and Brangus cows, respectively.

Reproductive performance was similar for the Brangus and F_2BA cows and both groups had lower reproductive performance than the F_1BA cows. The F_1BA cows were superior to the other two breed groups in pregnancy rate ($P<.0007$), calving rate ($P<.0001$) and weaning rate ($P<.0002$). Weaning rate of F_1BA (90.7%) was 28 and 35% higher, respectively, than the weaning rates of Brangus (70.8%) and F_2BA (67.1%) cows. No differences among the three cow breed groups were

TABLE 16. LEAST SQUARES MEANS ± STANDARD ERRORS FOR WEANING WEIGHT AND PREWEANING AVERAGE DAILY GAIN (ADG) OF CALVES BY COW BREED GROUP AND YEAR

Year	Cow breed group[a]		
	Brangus	F_1 BA	F_2 BA
1980			
Weaning weight, kg	201.6 ± 4.00	246.3 ± 4.0	204.7 ± 9.8
Preweaning ADG, kg	.672 ± .01	.831 ± .01	.692 ± .03
1981			
Weaning weight, kg	190.9 ± 4.1	214.7 ± 4.2	208.1 ± 9.6
Preweaning ADG, kg	.621 ± .01	.712 ± .01	.740 ± .01
1982			
Weaning weight, kg	234.8 ± 4.1	237.8 ± 4.6	236.4 ± 6.4
Preweaning ADG, kg	.803 ± .01	.815 ± .01	.812 ± .02
1983			
Weaning weight, kg	247.5 ± 4.3	257.7 ± 5.1	255.5 ± 6.4
Preweaning ADG, kg	.858 ± .01	.897 ± .01	.901 ± .02

[a] Interactions between cow breed group and year affected weaning weight ($P<.0009$) and preweaning average daily gain (ADG) ($P<.001$) of calves.

found for stillborn rate (P<.21), calf mortality from day 0 to 4 (P<.85), or from day 4 to weaning (P<.59). Values for these traits were consistently highest, however, for the F_2BA cows, and the F_2BA cows tended (P<.08) to have the lowest calf survival rate.

Assuming no inbreeding and negligible epistatic combination effects, differences found between most traits of the inter se mated populations are due to the sum of the heterosis levels and the additive genetic values for each of those traits (Koger, 1980; Peacock and Koger, 1980; Peacock et al., 1981). In the 1/2 B:1/2 A group, the F_1BA dams should have expressed maximum heterosis. Cows from the 3/8 B:5/8 A population, on the other hand should have retained about 47% of the maximum possible heterosis (Dickerson, 1973; Koger, 1980). The F_2BA cows should have lost about 50% the heterosis of the F_1BA cows, and therefore, should have retained about the same level of heterosis as the 3/8 B:5/8 A cows. The overall performance of the F_2BA cows tending toward the mean performance of the 3/8 B:5/8. This would indicate that the loss of heterosis from the F_1 to the F_2 generation was about what would be expected. Consequently, the 1/2 B:1/2 A population, under the conditions of this experiment, showed superior performance due to the highest heterosis levels. It is likely that as the F_1BA cows disappear from the system, and the proportion of F_2BA, F_3BA, etc., cows increases, the two inter se mated populations will tend to have similar performance. Another factor contributing to the observed differences may be the additive breed effects for certain traits. Cows from the 1/2 B:1/2 A population have 12.5% more Brahman and 12.5% less Angus in their genotypes than the 3/8 B:5/8 A, and therefore, should show superior values for size related traits where the Brahman breed has been shown to exceed the Angus (Peacock et al., 1977).

Summary

Performance of two Brahman-Angus crossbred populations, [3/8 B:5/8 A (Brangus) and 1/2 B:1/2 A (F_1BA)] mated inter se was compared in a study at the Everglades Research and Education Center, Belle Glade, Florida. Data for six complete mating seasons, that included 751 cow and 611 calf records, were used in the study. A 70-day breeding season started about January 1 each year. During the breeding season the Brangus and F_1BA and F_2BA cows were separated, and the Brangus cows bred to Brangus bulls and the F_1BA and F_2BA cows bred to F_1BA bulls. Each herd was grazed year-round on Roselawn St. Augustinegrass pastures grown on organic soils at a stocking rate of about 3.1 cow units per hectare. Response variables evaluated were cow productivity measured as kg of calf weaned per cow in the breeding herd and as kg of calf weaned as a percentage of cow weight, cow weight, calf performance and survival traits, and cow reproductive traits. Comparisons were made between the two inter se mating populations (3/8 B:5/8 A (Brangus) vs 1/2 B:1/2 A (F_1BA)), between Brangus vs F_1BA cow breed groups, and among the Brangus, F_1BA and F_2BA cows.

The F_1BA population had higher cow productivity ($P<.03$) and tended to have higher cow productivity per cwt ($P<.13$) than the Brangus population. Calves from F_1BA and F_2BA cows had heavier average birth ($P<.0001$) and weaning ($P<.0001$) weights, gained faster ($P<.0001$) and were younger at weaning ($P<.01$) than Brangus calves. Calf survival traits were similar for both inter se mated populations. Average

reproductive behavior of the 1/2 B:1/2 A inter se group was superior to that of the 3/8 B:5/8 A inter se group. The F_1BA cows had higher cow productivity (P<.0001) and cow productivity per cwt (P<.003) and were heavier P<.0001) than Brangus cows. Calves from F_1BA cows were heavier at birth (P<.0001) and weaning (P<.0001), and had higher preweaning ADG (P<.0001) than those from Brangus cows. Brangus calves were slightly older (P<.06) at weaning than F_2BA calves. Calf survival traits did not differ between these two cow breed groups. The F_1BA cows had higher pregnancy (P<.009), calving (P<.001), and weaning (P<.002) rates than Brangus cows.

Comparisons among Brangus, F_1BA and F_2BA cows, using data from the last 4 years when the three cow breed groups were represented in the experiment, were performed. The F_1BA cows were superior to the Brangus and F_2BA cows in both measures of cow productivity (P<.0001 and P<.004). The F_2BA cows were the lightest of all three cow types (P<.0001). Birth weights among calves from the different cow breed groups differed (P<.0001) with Brangus calves being the lightest. Preweaning ADG among the groups of calves was different (P<.0001). Calves from F_1BA and F_2BA cows had higher rates of gain than the Brangus group calves. Breed group of cow affected (P<.0003) weaning weights, and calves from F_1BA cows were heavier than those from Brangus and from F_2BA cows. Calves from F_2BA cows were the youngest at weaning, followed by calves from F_1BA and Brangus cows. No significant difference (P<.08) was found among the three cow breed groups for calf survival traits, although, survival rate of calves from F_2BA cows tended to be the lowest. Reproductive behavior of F_1BA cows was superior to that of the other two breed groups of cows.

SUMMARY AND CONCLUSIONS

Two experiments were conducted at the Everglades Research and Education Center, Belle Glade, Florida, to study the effects of breeding season on the productivity of a commercial cow-calf operation and to compare performance of two Brahman-Angus inter se mated populations.

In the first experiment, three 70-day breeding seasons (November 1-January 10, January 1-March 11, and February 15-April 25) were established and 26 Beefmaster cows were assigned at random, within age classes, to each of the three breeding seasons. Cows were mated to certified Beefmaster bulls and all herds were grazed continuously on St. Augustinegrass pastures grown on organic soils at a stocking rate of about 3.2 animal units per hectare. Response variables evaluated included cow productivity measures, calf growth and survival parameters, and reproductive behavior of cows.

Breeding season did not significantly affect any of the response variables. Except for calf birth and survival rates, year affected ($P<.05$) all response variables. Breeding season x year interactions affected calf weaning weight, cow weight ($P<.0001$) and cow productivity ($P<.01$). Age of dam affected pregnancy ($P<.01$), calving ($P<.01$) and weaning ($P<.06$) rates, and cow productivity ($P<.06$).

The performance of two Brahman-Angus crossbred populations mated inter se was compared in the second experiment. The two populations were 3/8 B:5/8 A (Brangus) and 1/2 B:1/2 A (F_1BA). Data utilized included 751 cow and 611 calf records collected over a 6-year period.

All herds grazed continuously on St. Augustinegrass pastures grown on organic soils at a stocking rate of about 3.1 animal units per hectare. The response variables analyzed included cow productivity measures, calf growth and survival parameters, and reproductive behavior of cows. Comparisons of the two inter se mated populations showed higher cow productivity ($P<.03$) and calf growth parameters ($P<.0001$) for the F_1BA population. Calf survival traits were similar for the two mating groups, and overall reproductive behavior of the F_1BA population dams was superior to that of the Brangus. Comparisons were also made among Brangus, F_1BA and F_2BA cow breed groups. Performance of the F_1BA cows and their F_2BA calves was superior to that of both Brangus and F_2BA cows and their calves. Except for birth weight and preweaning ADG, performance of the F_2BA cows and their calves tended to be similar to that of Brangus cows and calves. Significant effects for cow breed group x year interactions were found for several traits.

It can be concluded that, for the conditions of this study in south Florida, no single breeding season appeared to be the best. Thus, the producer has the option to select, from within the time period studied, the breeding season that will best suit his particular production and marketing circumstances.

Comparing the two inter se mated populations, the F_1BA population was more productive than the Brangus population; however, performance of the F_2BA cows tended to regress to that of Brangus cows. Thus, it is reasonable to speculate, that as the F_1BA cows disappear from the system and the F_2BA, F_3BA, etc., generation cows increase in numbers, productivity of the two inter se mated populations would tend to be similar.

LITERATURE CITED

Bagley, P. C., J. C. Carpenter, J. I. Feazel, F. G. Hembry, D. C. Huffman and K. L. Koonce. 1987. Influence of calving season and stocking rate on beef cow-calf productivity. J. Anim. Sci. 64:687.

B.I.F. 1986. Guidelines For Uniform Beef Improvement Programs (5th Ed.). Beef Improvement Federation, North Carolina.

Brown, C. J. 1960. Influence of year and season of birth, sex, sire, and age of dam on weights of beef calves at 60, 120, 180 and 240 days of age. J. Anim. Sci. 19:1062.

Cornwell, D. G., J. G. Wasdin and J. F. Hentges, Jr. 1984. Effect of production programs with fall vs winter calving seasons on production in Angus and Brahman herds. Florida Beef Cattle Res. Rep. Univ. of Florida, Gainesville. p 18.

Crockett, J. R., M. Koger and D. E. Franke. 1978a. Rotational crossbreeding of beef cattle: Reproduction by generation. J. Anim. Sci. 46:1163.

Crockett, J. R., M. Koger and D. E. Franke. 1978b. Rotational crossbreeding of beef cattle: Preweaning traits by generation. J. Anim. Sci. 46:1163.

Cundiff, L. V. 1970. Experimental results on crossbreeding cattle for beef production. J. Anim. Sci. 30:694.

Cundiff, L. V. 1977. Foundations for animal breeding research. J. Anim. Sci. 44:311.

Dickerson, G. 1969. Experimental approaches in utilizing breed resources. Anim. Breed. Abstr. 37:191.

Dickerson, G. 1973. Inbreeding and heterosis in animals. P.54-77. In Proc. of the Animal Breeding and Genetics Symp. in Honor of Dr. Jay L. Lush. A.S.A.S., Champaign, IL.

Franke, D. E., T. D. Bidner and M. S. Taylor. 1977. Comparing growth and carcass characteristics of beef cattle. Louisiana Agr. 21:8.

Gregory, K. E. and L. V. Cundiff. 1980. Crossbreeding in beef cattle: Evaluation of systems. J. Anim. Sci. 51:1224.

Gregory, K. E., L. V. Cundiff, G. M. Smith, D. B. Laster and H. A. Fitzhugh, Jr. 1978. Characterization of biological types of cattle-Cycle II: I. Birth and weaning traits. J. Anim. Sci. 47:1022.

Gregory, K. E., G. M. Smith, L. V. Cundiff, R. M. Koch and D. B. Laster. 1979. Characterization of biological types of cattle-Cycle III: I. Birth and weaning traits. J. Anim. Sci. 48:271.

Harvey, W. H. 1987. Harveys Mixed Model Least-Squares and Maximum Likelihood Computer Program (PC-1). The Ohio State University, Columbus.

Isea, I. V. 1985. The effects of milk yield, milk fat percent and fat yield of Brown Swiss x Angus crossbred cows on calf preweaning growth. M. S. Thesis. Univ. of Florida, Gainesville.

Koch, R. M. and R. T. Clark. 1955. Influence of sex, season of birth and age of dam on economic traits in range beef cattle. J. Anim. Sci. 14:386.

Koch, R. M., G. E. Dickerson, L. V. Cundiff and K. E. Gregory. 1985. Heterosis retained in advanced generations of crosses among Angus and Hereford cattle. 1985. J. Anim. Sci. 60:1117.

Koger, M. 1973. Breeding for the American Tropics. P. 41-47. In Crossbreeding Beef Cattle. Series 2. Koger, M., Tony J. Cunha and A. C. Warnick (Ed.). University of Florida Press, Gainesville.

Koger, M. 1977. Pasture programs and beef cattle breeding systems for beef production in north central Florida. Experimental phase No. 3. Florida Agr. Exp. Sta. Tech. Bull. No. 789.

Koger, M. 1980. Effective crossbreeding systems utilizing zebu cattle. 1980. J. Anim. Sci. 50:1215.

Koger, M., W. G. Blue, G. B. Killinger, R. E. L. Greene, H. C. Harris, J. M. Myers, A. C. Warnick, and N. Gammon Jr. 1983a. Beef production, soil and forage analyses, and economic returns from eight pasture programs in north central Florida. Experimental phase No. 1. Florida Agr. Exp. Sta. Tech. Bull. No. 631.

Koger, M., W. G. Blue, G. B. Killinger, R. E. L. Greene, J. M. Myers, N. Gammon, Jr., A. C. Warnick, and J. R. Crockett. 1983b. Production response and economic returns from five pasture programs in north central Florida. Experimental phase No. 2. Florida Agr. Exp. Sta. Tech. Bull. No. 740.

Koger, M., Tony J. Cunha and A. C. Warnick (Ed.). 1973. Crossbreeding Beef Cattle. Series 2. University of Florida Press, Gainesville.

Koger, M., J. S. Mitchell, R. W. Kidder, W. C. Burns, J. F. Hentges, Jr. and A. C. Warnick. 1967. Factors influencing survival in beef calves. J. Anim. Sci. 26:205 (Abstr.).

Koonce, K. L. and E. U. Dillard. 1967. Some environmental effects on birth weight and gestation length in Hereford cattle. J. Anim. Sci. 26:205 (Abstr.).

Lasley, J. F. 1981. Beef Cattle Production. Prentice Hall, Inc, Englewood Cliffs, New Jersey.

Laster, D. B. and K. E. Gregory. 1973. Factors influencing peri- and early postnatal calf mortality. J. Anim. Sci. 37:1092.

Long, C. R. 1980. Crossbreeding for beef production: Experimental results. J. Anim. Sci. 51:1197.

Long, C. R. and K. E. Gregory. 1974. Heterosis and breed effects in preweaning traits of Angus, Hereford and reciprocal cross calves. J. Anim. Sci. 39:11.

Lopez-Fanjul, C. 1974. Selection from crossbred populations. Anim. Breed. Abstr. 42:403.

Lush, J. L. 1946. Chance as a cause of changes in gene frequency within pure breeds of livestock. Am. Nat. 80:318.

Marlowe, T. J. and J. A. Gaines. 1958. The influence of age, sex and season of birth of calf, and age of dam on preweaning growth rate and type score of beef calves. J. Anim. Sci. 17:706.

Marlowe, T. J., C. C. Mast and R. R. Schalles. 1965. Some nongenetic influences on calf performance. J. Anim. Sci. 24:494.

Meade, J. H., Jr., R. W. Kidder, M. Koger and J. R. Crockett. 1963. Environmental factors affecting weaning weights of beef cattle in the Everglades. Florida Agr. Exp. Sta. Tech. Bull. No. 663.

Minyard, J. A. and C. A. Dinkel. 1965. Weaning weight of beef calves as affected by age and sex of calf, and age of dam. J. Anim. Sci. 24:1067.

Notter, D. R., L. V. Cundiff, G. M. Smith, D. B. Laster and K. E. Gregory. 1978. Characterization of biological types of cattle. VI. Transmitted and maternal effects on birth and survival traits in progeny of young cows. J. Anim. Sci. 46:892.

Oliver, W. M. 1987. Lifetime performance of purebred and crossbred beef cows in the coastal plain. Louisiana Agr. Exp. Sta. Bull. No. 790.

Olson, T. A. 1982. Inter se mating. Proc. 31st Annu. Beef Cattle Short Course. Univ. of Florida, Gainesville. p.20.

Olson, T. A., M. Koger and D. D. Hargrove. 1984. Heterosis retention in Brown Swiss x Angus F_2 crossbreds for pregnancy rate and calf birth and weaning weights. 1984. J. Anim. Sci. (Suppl.1):170.

Pate, F. M., J. R. Crockett and J. D. Phillips. 1985. Effect of calf weaning age and cow supplementation on cow productivity. J. Anim. Sci. 61:343.

Peacock, F. M., W. G. Kirk and M. Koger. 1966. Factors affecting the weaning weight of range calves. Florida Agr. Exp. Sta. Tech. Bull. No. 578A.

Peacock, F. M. and M. Koger. 1980. Reproductive performance of Angus, Brahman, Charolais and crossbred dams. J. Anim. Sci. 50:689.

Peacock, F. M., M. Koger, J. R. Crockett and A. C. Warnick. 1977. Reproductive performance and crossbreeding Angus, Brahman and Charolais cattle. J. Anim. Sci. 44:729.

Peacock, F. M., M. Koger, W. G. Kirk, E. M. Hodges and J. R. Crockett. 1976. Beef production of Brahman, Shorthorn, and their crosses on different pasture programs. Florida Agr. Exp. Sta. Tech. Bull. No. 780.

Peacock, F. M., M. Koger, T. A. Olson and J. R. Crockett. 1981. Additive genetic and heterosis effects in crosses among cattle breeds of British, European and zebu origin. J. Anim. Sci. 52:1007.

Philips, R. W. 1961. Animal genetic resources. World Anim. Rev. 3(13):28-33.

Preston, T. R. and M. B. Willis. 1970. Intensive Beef Production. Pergamon Press, New York.

Prichard, D. L., D. D. Hargrove and T. T. Marshall. 1982. Influence of period of birth and breed group on preweaning performance traits of beef calves. Florida Beef Cattle Res. Rep. Univ. of Florida, Gainesville. p 30.

Restle, J., D. D. Hargrove and M. Koger. 1986. Comparison of upgrading and rotational crossbreeding for genetic improvement of a Brahman-native population of beef cattle. Florida Agr. Exp. Sta. Tech. Bull. No. 851.

Reynolds, W. L., T. M. DeRouen, S. Moin and K. L. Koonce. 1979. Factors affecting pregnancy rate of Angus, zebu and zebu-cross cattle. J. Anim. Sci. 48:1312.

Reynolds, W. L., T. M. DeRouen, S. Moin and K. L. Koonce. 1980. Factors influencing gestation length, birth weight and calf survival of Angus, zebu and zebu cross beef cattle. J. Anim. Sci. 51:860.

Rovira, J. 1972. Reproduccion y Manejo de los Rodeos de Cria. Ed. Hemisferio Sur, Montevideo, Uruguay.

SAS. 1986. Statistical Analysis System. SAS Institute Inc., Raleigh, NC.

Smith, G. M., D. B. Laster and K. Gregory. 1976. Characterization of biological types of cattle. I. Dystocia and preweaning growth. J. Anim. Sci. 43:27.

Spitzer, J. C. and L. R. Sprott. 1986. A total beef herd management plan: Success revisited. J. Anim. Sci. (Abstr. S. section):23.

Thrift, F. A. and D. K. Aaron. 1987. The crossbred sire: Experimental results for cattle. J. Anim. Sci. 65:128.

Vernon, E. H., W. R. Harvey and E. J. Warwick. 1964. Factors affecting weight and score of crossbred-type calves. J. Anim. Sci. 23:21.

Warnick, A. C. 1963. Reproductive Performance. P.82-87. In Crossbreeding Beef Cattle. T. J. Cunha, M. Koger and A. C. Warnick (Ed.). University of Florida Press, Gainesville.

Warwick, E. J. and J. E. Legates. 1979. Breeding and Improvement of Farm Animals (7th Ed.). McGraw Hill Book Company, New York.

Wiltbank, J. N. 1970. Research needs in beef cattle reproduction. J. Anim. Sci. 31:755.

Wiltbank, J. N., E.J. Warwick, E. H. Vernon and B. M. Priode. 1961. Factors affecting net calf crop in cattle. J. Anim. Sci. 20:409.

Woodward, R. R. and R. T. Clark. 1959. A study of stillbirths in a herd of range cattle. J. Anim. Sci. 18:85.

BIOGRAPHICAL SKETCH

Alexis Pourrain was born January 12, 1947, in Puerto Belgrano, Provincia de Buenos Aires, Argentina. From 1952 to 1955, he lived in New York City where his father was a member of the Argentine diplomatic delegation to the United States.

He graduated from high school in 1966 in the city of Buenos Aires. He then attended the College of Agriculture, Facultad de Agronomia y Veterinaria de Buenos Aires, graduating in 1972 with the title of Ingeniero Agronomo, with a specialty in animal production. Until 1976, he worked in the Animal Science Department of the same college, in the area of animal nutrition. He served as technical advisor for the Banco de la Nacion Argentina-IDB agreement for agricultural development of marginal areas of Argentina from 1976 to 1978. He joined the permanent staff of the Instituto Nacional de Tecnologia Agropecuaria (I.N.T.A.), in 1978, as Chief of the Extension Agency of Mercedes, Provincia de Corrientes.

He entered the Graduate School of the University of Florida in January 1982. He received the Master of Science degree in animal science in May 1984, and returned to his former position in his country.

In August 1986 he returned to the U.S.A. and since then has been working toward the Doctor of Philosophy degree in animal science at the

University of Florida, Gainesville, Florida. In 1988 he was appointed as director (in absentia) of the Experimental Station (INTA) of Mercedes, Provincia de Corrientes, Argentina.

He is married to Rita Elsa Diaz, with whom he has two children, Alexis and Javier.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Don D. Hargrove

Don D. Hargrove, Chairman
Professor of Animal Science

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Timothy A. Olson

Timothy A. Olson
Associate Professor of Animal Science

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Charles J. Wilcox

Charles J. Wilcox
Professor of Dairy Science

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Findlay M. Pate

Findlay M. Pate
Professor of Animal Science

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Peter E. Hildebrand
Professor of Food and Resource Economics

This dissertation was submitted to the Graduate Faculty of the College of Agriculture and to the Graduate School and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

August 1988

J. Wayne Mishoe

Dean, College of Agriculture

Dean, Graduate School